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Variable Star Field 96′ South Preceding the Nucleus of the Andromeda Galaxy

WALTER BAADE AND HENRIETTA H. SWOPE
Mount Wilson and Palomar Observatories, Carnegie Institution of Washington, California Institute of Technology
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Field IV in M31 is situated 96′ south preceding the nucleus in the sixth spiral arm. Twenty Cepheids were found in this area and from their periods and color the absorption free distance modulus to M31 is estimated to be $24^{m}.20$, corrected for $+0^{m}.16$ reddening. There are also 7 other variables that are 2 magnitudes fainter than the Cepheids which have been called "Population II" variables. The color–magnitude diagrams show the stars brighter than $M_V = -2^{m}.7$ in M31. They show main-sequence stars, the upper portion of the red giant branch, and possibly a few G and K type supergiants.

1. INTRODUCTION

DR. Baade was interested in extending his knowledge of the stellar populations and obtaining a more accurate distance to the great Andromeda galaxy. For this project he wanted to examine the variables, particularly the Cepheids. He selected three fields, shown in Plate I, that are 15′, 35′, and 50′ south preceding the nucleus of M31. Field I he described as amorphous; Field II, the middle one, he selected because it lies in a region of mixed character; and Dr. S. Gaposchkin (1962) has published data on the variables in that area; Field III, 50′ away from the center, is in a well-developed spiral arm. The data for Fields I and III will be published in subsequent papers.

Many Cepheids were found in the three fields, but the preliminary period–luminosity diagram showed a great dispersion, which is attributed to varying absorption within M31 (Baade and Swope 1955). In order to avoid this obstacle in obtaining a good distance modulus, Baade selected a fourth field 96′ south preceding the nucleus, in what he has described as the sixth spiral arm (Baade 1963) and which he hoped would show the minimum of absorption. The outline of this arm is traced by several associations of blue stars and from patches of ionized hydrogen. It is this field that is discussed in this paper.

During 1952 through 1954, Baade accumulated about 100 plates. In order to find variables, he blinked 21 pairs of plates. He marked 60 stars as suspected variables, 54 of which have been verified.

Baade also blinked 3 pairs of photovisual plates and found about 100 more variables that do not appear on the photographic plates, indicating that they are red variables either of irregular or long-period type. These variables have not yet been measured.

The magnitudes of the variables discussed in this paper were first estimated by eye, and the types of variations were thus determined. The Cepheids, eclipsing stars, and a few others not too near the edge of the field were later measured with an iris photometer. This is the only one of the four fields in M31 where this is possible, since the stars in the other fields are too crowded, which affects the photometric measures. The magnitudes of the variables not measured by the photometer were estimated twice by eye and the means taken.

2. MAGNITUDE STANDARDS

The magnitudes for this field were derived in very much the same way as were those for the Draco system (Baade and Swope 1961). A sequence of stars was selected in the center of the region and additional stars chosen to serve as local standards around each variable. These sequences are marked on Plate II and the magnitudes listed in Tables I and II. To obtain a standard scale, four plates were selected because of their good quality images over a large area of the plate. The iris photometer measures of each plate were reduced to one plate and means taken.

Because this fourth field has only 20 Cepheids, widely distributed, it was decided to check whether magnitude correction for distance from the plate center would be necessary. (This was not done for the Draco system as there were many RR Lyrae variables avail-

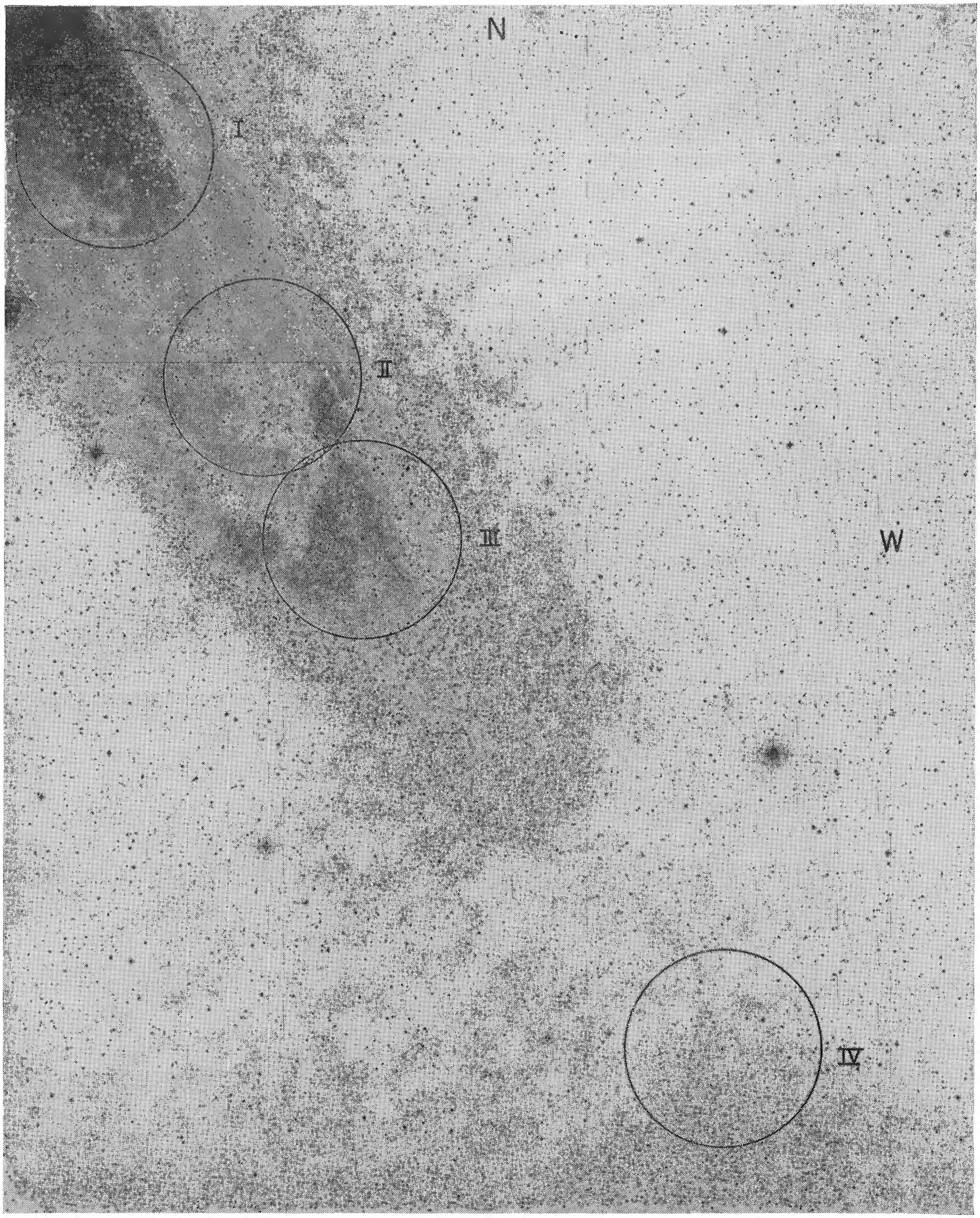

PLATE I. Baade's four variable star fields of M31. The plate is an enlargement of a portion of a 48-inch Schmidt plate. The circles represent the good area of the 200-inch plates.

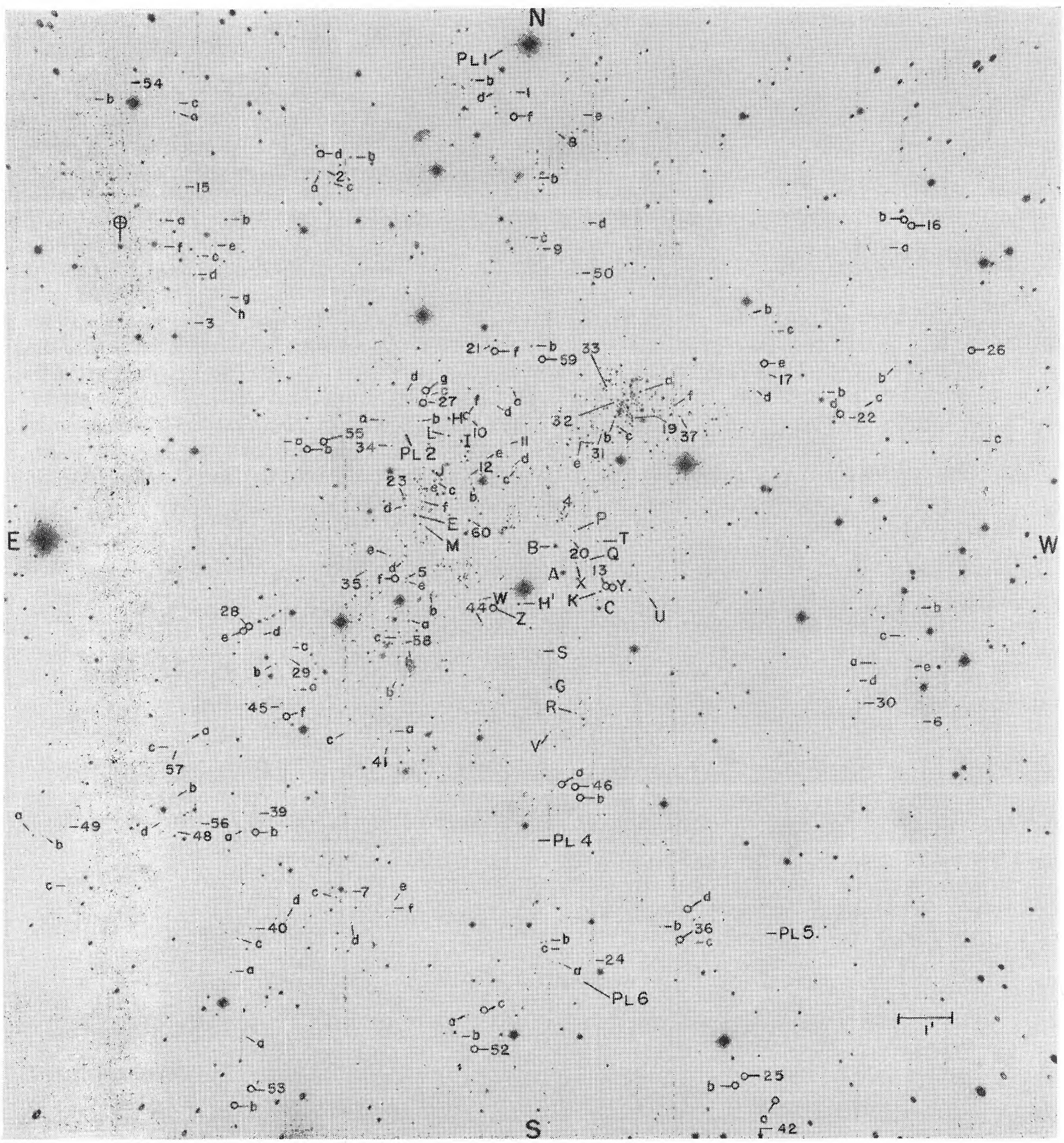

Plate II. Field IV, 96′ south preceding nucleus of M31 from a 200-inch 103a-O plate. Capital letters, standard sequence; small letters, local sequences. Variables are numbered; objects marked PL1–6 are planetary nebulae.

able in the center of the plate on which to base the various relationships.) For this purpose Baade had taken a series of plates offset from the center. He outlined the area of good images on each plate. The standard stars falling in this area were used to form a reduction curve and the reduced readings for the other standards and local standards in this area were read off. The differences between the scale reading derived from the centered plates and from the offset plates were then plotted against distance from the plate center and a mean correction curve formed. No sensible correction was necessary for the variables within 5.5 min of arc or 30 mm from the plate center. The scale correction was applied directly to the photometric readings because, at any given distance, it is the same for stars of all brightnesses, but when the scale reading is translated into magnitudes, the correction varies. As an example, at 8′.8 of arc from the plate center, a star

1963AJ.....68..435B

TABLE I. Primary sequence of M31, Field IV.

Sequence	Arp, photoelectric (1950)				Adopted, photographic (1960)		
Star	B	V	B−V	U−B	B	V	B−V
A	16.24	15.54	+0.70	+0.19	16.24	15.52	+0.72
B	16.79	15.92	+0.87	+0.46	16.80	15.93	+0.87
C	16.97	16.26	+0.71	−0.02	16.98	16.30	+0.68
E	17.54	16.56	+0.98	+0.78	17.54	16.56	+0.98
G	17.73	17.06	+0.67	+0.12	17.73	17.10	+0.63
H	18.26	17.56	+0.70	...	18.24	17.55	+0.69
H′	...	...	...	...	18.38	17.87	+0.51
I	18.54	17.49	+1.05	+1.15	18.54	17.45	+1.09
J	19.26	19.51	−0.25	−1.12	19.25	19.51	−0.26
K	19.17	18.47	+0.70	...	19.20	18.55	+0.65
L	19.27	18.74	+0.53	...	19.28	18.72	+0.56
M	19.66	19.66	0.00	−0.19	19.65	19.66	−0.01
P	20.54	20.58	−0.04	−1.06	20.50	20.66	−0.16
Q	20.47	19.42	+1.05	...	20.51	19.43	+1.08
R	21.01	20.94	+0.07	−0.91:	21.03	21.23	−0.20
S	21.29	20.81	+0.48	+0.25	21.36	20.63	+0.73
T	21.12	20.25	+0.87	...	21.31	20.15	+1.16
U	21.30	21.03	+0.27	...	21.35	21.04	+0.31
V	21.49	21.64	−0.15	−0.87	21.48	21.56	−0.08
W	21.58	21.38	+0.20	−0.75	21.51	21.57	−0.06
X	21.71	21.53	+0.18	...	21.69	21.53	+0.16
Y	22.38	22.05	+0.33	...	22.37	22.05	+0.32
Z	22.70	22.40	+0.30	...	22.60	22.40	+0.20

that is brighter than $20^m.5$ has a scale correction of $+12$, which translates to $-0^m.34$, whereas one fainter than $21^m.5$ has the same scale correction but in magnitude it is $-0^m.52$.

The standard scale readings for the main sequence and the corrected outlying local sequences now gave a consistent system and the variables measured on the iris photometer were reduced to this system. Magnitudes for the standard scale were first obtained from plates of Field IV and Selected Area 68 ($0^h14^m00^s$ $+15°33'.6$, 1950) that were taken in series and developed together. S. A. 68 magnitudes are based on extensive photoelectric photometry by Stebbins, Whitford, and Johnson (1950) and by Baum (unpublished). During one session a plate of S. A. 68 was measured on the iris photometer, then a plate of Field IV taken on the same night, and again the S. A. 68 plate. The photometer readings of the selected area were plotted against the magnitude and a reduction curve drawn through the points. The photometer readings of Field IV were then transformed to magnitudes by the use of the curve. The mean magnitudes obtained by transfer needed a systematic correction of -0.08, but otherwise compared favorably with the later magnitudes obtained from a direct photoelectric sequence.

In 1959 H. C. Arp secured photoelectric measures of

TABLE II. Local sequences for variables.

Star Var.	Seq.	B	V	C-M No.	Star Var.	Seq.	B	V	C-M No.	Star Var.	Seq.	B	V	C-M No.
5, 35	b	20.71	20.30	A 151	21, 59	b	21.20	21.37	B 1	28, 29	a	21.21	21.12	B 203
	c	21.21	21.15	297		c	21.36	19.66	281	45	b	21.59	21.40	210
	d	21.30	21.24	296		d	22.00	21.95	278		c	22.04	21.90	211
	e	21.46	21.50	298		f	22.80	22.61	...		d	22.25	20.72	222
	f	22.33	22.25	...							e	22.57	21.06	224
					23	c	20.50	20.66	A 239		f	22.57	22.29	...
10, 11	b	21.39	21.42	...		d	21.00	21.09	290					
12	c	21.57	21.23	A 226		e	21.14	21.18	282	41	a	21.27	21.41	B 180
	d	22.00	21.39	225		f	21.75	21.61	280		b	21.70	20.69	A 162
	e	22.29	22.16	...							c	22.25	21.86	B 188
	f	22.74	22.33	...	27, 34	a	20.85	20.65	B 256					
						b	21.24	20.62	267	46	a	22.50	21.77	B 146
19, 31	a	19.32	19.61	B 64		c	21.60	21.71	268		b	22.70	21.17	144
32, 33	b	19.89	20.04	46		d	21.87	21.85	265					
37	c	20.30	20.41	48		g	22.86	22.36	...	55	a	22.45	20.60	...
	e	20.52	20.35	A 55							b	22.90	22.60	...
	f	20.70	19.09	B 80										
	g	21.12	18.99	51						58	a	21.19	20.40	A 154
											b	21.96	22.06	159
											c	22.19	20.70	156
Sequences corrected for distance from plate center														
2	a	20.94	19.15		6, 30	a	20.56	18.93		22	b	21.39	20.32	
	b	21.29	20.05			b	20.74	21.02			c	22.15	22.33	
	c	21.75	20.07			c	21.16	21.49			d	22.71	21.90	
	d	22.30	21.50			d	21.98	21.97						
						e	22.45	...		24	a	20.78	20.17	
3, 15	a	19.56	18.72								b	21.24	21.35	
	b	20.16	18.63		8, 9	b	20.58	19.00			c	22.01	21.23	
	c	20.35	19.20		50	c	20.96	19.47						
	d	20.72	19.68			d	21.56	20.92		36	b	21.71	20.16	
	e	21.13	19.63			e	22.23	22.14			c	22.12	22.08	
	f	21.50	20.07								d	22.49	21.03	
	g	21.80	20.38		17	b	21.07	20.05						
	h	21.85	21.10			c	21.64	20.20		48, 56	a	21.60	21.83	
						d	22.13	22.25		57	b	22.09	22.10	
						e	22.72	22.64			c	22.27	22.32	
											d	22.27	22.35	

Eye-estimated sequences

Star Var.	Seq.	B	Star Var.	Seq.	B	Star Var.	Seq.	B	Star Var.	Seq.	B
1	b	20.75	25	a	21.1	40	a	20.5	52	a	21.55
	d	21.95		b	22.1		c	20.9		b	22.2
	f	22.55					d	21.1		c	22.75
			26	b	21.3						
7	c	20.95		c	21.7	42	a	21.45	53	a	21.75
	d	21.40		d	22.6		b	22.0		b	22.35
	e	21.85									
	f	22.05	39	a	22.0	49	a	20.0	54	a	20.3
				b	22.55		b	20.7		b	20.8
16	a	22.1					c	21.15		c	21.4
	b	22.4									

TABLE III. 54 variables.

Var. No. (1)	B_{max} (2)	B_{min} (3)	Photometry (4)	Type (5)	Period (6)	1/p (7)	B–V (8)	Dist. (9)	Zero Phase (10)	Note (11)
	m	m						mm		
1	21.25	(22.5	a	Eclipsing	511	0.0001957	–0.20	50	0.200	
2	21.18	22.34	b, c	Cepheid	4.3678	.22895	+0.59	47	.100	
3	20.40	22.00	b, c	Cepheid	12.7144	.078651	0.91	43	.000	
4	19.60	20.70	a	Semiregular			2.25	8		
5	20.69	21.97	b, c	Cepheid	12.840	.07788	1.01	11	.550	
6	21.00	22.30	b	Semiregular	Cycles of 85± days		0.90	42		
7	20.75	21.35	a	Eclipsing			0.08	36		1
8	20.60	21.70	a, c	Cepheid	9.6432	.10370	0.74	47	.300	
9	20.77	21.85	b, c	Cepheid	8.5092	.11752	0.76	34	.950	
10	21.81	22.55	b, c	Cepheid	3.0431	.32861	0.60	18	.400	
11	21.44	21.90	b, c	Cepheid	2.9776	.335839	+0.59	14	.050	
12	21.54	22.08	b	Eclipsing	2.32415	.430265	–0.08	12	.500	
13	22.11	22.83	b, c	Cepheid	3.8030	.26295	+0.86	8	.900	
15	19.78	21.40	a, c	Cepheid	21.263	.04703	0.95	53	.750	
16	22.20	22.80	a	Cepheid	2.5136	.39783	....	54	.600	
17	21.20	22.36	b, c	Cepheid	6.7317	.14855	+0.98:	33	.700	
19	19.80	20.40	a	Irregular			–0.06	20		
20	21.0	22.4	a	Semiregular	Cycles of 150± days		+1.07	7		
21	21.64	22.66	b, c	Cepheid	3.3477	.029871	0.63	25	0.000	
22	21.45	22.71	b, c	RV Tauri	37.30	.02681	+0.74	37	1.100	
23	20.75	21.15	a	Eclipsing	6.3235	.15814	–0.07	15	0.950	2
24	21.00	21.80	b, c	Semiregular	46.25	.02162	+0.80	38	0.500	
25	21.75	22.83	a	RV Tauri	39.43	.02536	....	55	1.800	
26	21.75	22.35	a	Cepheid	3.9451	.25348	....	52	0.850	
27	21.85	22.69	b, c	Cepheid	2.5928	.38568	0.71	21	.300	
28	21.95	(23.0	a	Irregular			+1.23	27		
29	21.54	21.96	b	Eclipsing	11.905	.08400	–0.17	24	.450	
30	20.78	21.98	b, c	Cepheid	12.8783	.07765	+1.05	36	.500	
31	20.08	20.82	b, c	Cepheid	13.3360	.074985	0.66	18	.700	
32	20.60	21.00	b	Irregular			+1.95	21		
33	20.35	20.70	b	Irregular			–0.27	22		
34	20.95	21.71	a, c	Semiregular	62.0	.01613	+0.75	19	.100	3
35	21.85	22.75	b	Eclipsing	2.47225	.40449	0.03	16	.350	
36	22.05	22.89	b, c	Cepheid	3.5935	.27829	+0.78	39	.250	
37	20.00	20.30	b	Short			–0.05	23		
39	22.30	22.70	b	Cepheid?			....	35		
40	20.90	21.45	a	Eclipsing?			0.00	45		4
41	21.75	22.15	b	Irregular			+0.11	20		
42	21.63	22.25:	a	Cepheid	3.0983	.32276	....	64	.550	
44	21.60	21.85	b	Eclipsing			0.00	6		
45	21.95	22.70	a	Eclipsing			0.37	27		5
46	22.62	23.30:	b, c	Cepheid	3.7110	.26947	0.93:	21	.450	
48	22.34	22.96	b, c	Cepheid	3.4032	.29384	0.73	43	.800	
49	20.5	21.2	a	Irregular			....	52		
50	21.0	21.6	b	Irregular			2.02	32		
52	22.15	22.75	a	....			....	48		
53	22.35	22.99	a	W Virginis	19.87	.05032	....	57	.330	
54	20.4	21.1	a	Irregular			....	65		
55	22.40	23.15:	a, c	W Virginis	19.26	.05193	0.93	25	.150	
56	21.5	22.2	b	Irregular			0.20	40		
57	21.86	22.20	b, c	Semiregular	53.5	.0187	0.70	38	0.900	
58	21.5	22.0	b	Irregular			1.97	13		
59	22.30	(23.0	a	Long period	230	.00435	+1.80	23		
60	18.90	19.48	b	Eclipsing	7.3303	0.13642	–0.23	9		

Explanation of Table III

Col. (4) Photometry: a - mean of 2 eye estimates
b - iris photometer, photographic plates
c - iris photometer, photovisual plates

(7) Reciprocal period used in computing phases of Tables A, B, and C.

(8) Color index of eclipsing and irregular variables derived from 3 or 4 pairs of photographic and photovisual plates.

(9) Distance from plate center to indicate reliability of magnitude and amplitude.

(10) Computed phase that corresponds to zero phase of Figs. 2 to 9.

(11) Notes.
1. Five minima, 6″ preceding 15^m star.
2. 1″ preceding a $21^m.05$ star.
3. 1″ following a faint companion.
4. Two minima.
5. 3″ south of a $21^m.20$ star.

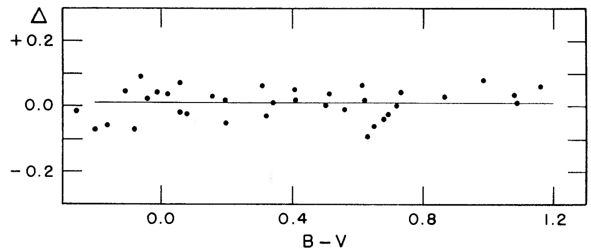

FIG. 1. Effect of GG 1 and GG 13 filters on magnitudes. Ordinate, difference in magnitude GG 1–GG 13; abscissa, Arp's photoelectric measures of $B-V$.

22 stars in Field IV (Table I). To adjust them to the 200-inch plates independently of the former standards and to extend the sequence to other comparison stars, two series of 103a-O plates were selected. They were plates that had been measured for variable stars and were chosen on the basis of the least scatter around preliminary reduction curves, which indicated a good field. The original photometric measures were plotted against Arp's photoelectric magnitudes, a smooth curve was drawn and new photographic magnitudes read off. One series of seven plates had been taken with a GG 1 filter and the other series of 8 plates with a GG 13 filter. The magnitudes from the two series were compared to determine whether there was a systematic difference between the series dependent on the color indices, but no such difference was detected. This is shown in Fig. 1, where the difference in magnitudes of the two filter series is plotted against the photoelectric $B-V$ value.

That there is no evident systematic difference between the two series of plates is due in part to the fact that Baade always used the $f/3.67$ Ross corrector, which cuts out much of the ultraviolet light and reduces by 40% the predicted difference (Arp 1961) between the GG 1 and GG 13 filters that were used with the 103a-O plates. The difference is further minimized because the $B-V$ measures of Fig. 1 have a limited range between -0.2 and $+1.2$, and because the photometer readings of both series were reduced by the same photoelectric sequence.

The photovisual magnitudes are based on the measures of four 103a-D plates taken with a GG 11 filter. The final adopted B and V magnitudes used for the 200-inch plates are given in the right-hand columns of Table I. Between the photoelectric and photographic sequences there are 4 differences in $B-V$ greater than $0^m.20$. Star T, a red star, might have varied between 1957, the time of the last plate, and 1959, when Arp made his measures. Stars R, S, and W have large unaccountable differences in V.

The local standards corrected for distance from plate center and the variables for which they were used are

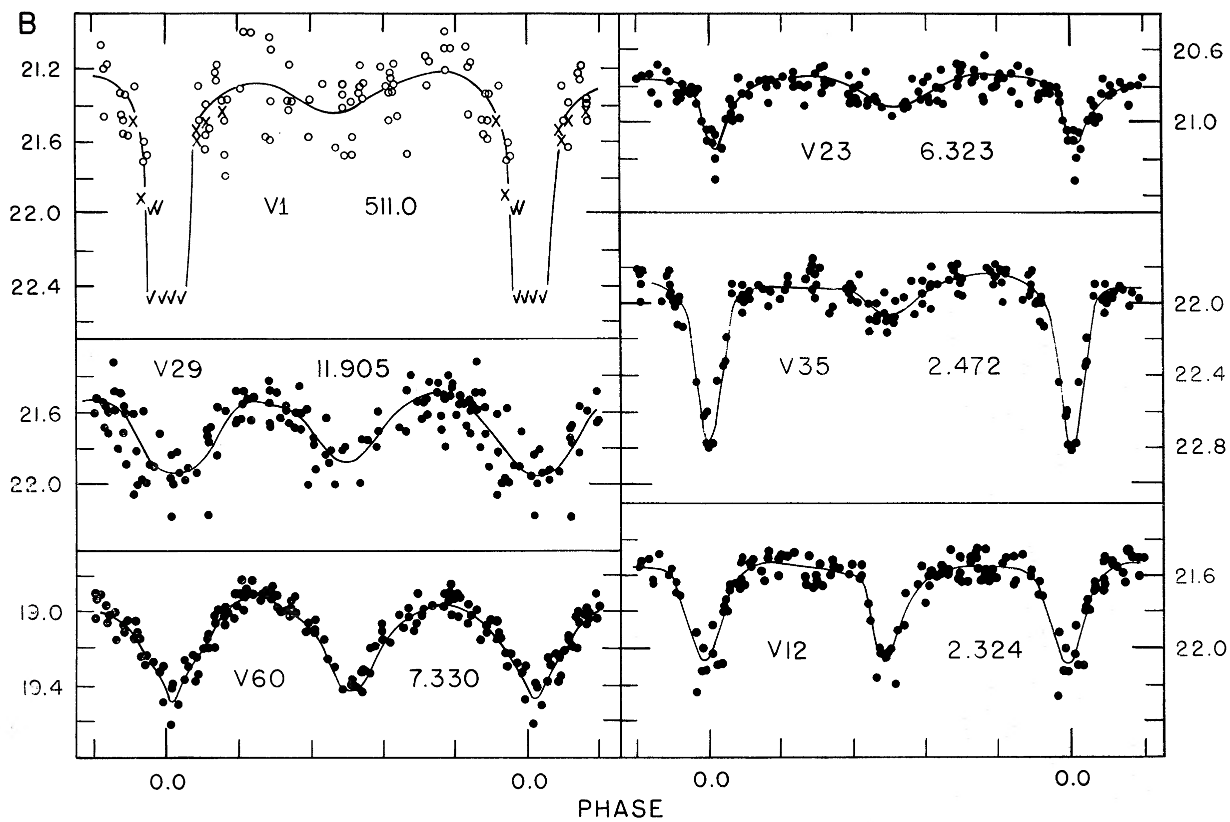

FIG. 2. Eclipsing binaries. Crosses for V1 are photovisual observations in 1957 adjusted by $-0^m.10$; check marks, observations below plate limit. Magnitudes of V1 and V23 are eye estimates.

listed in Table II. The last column gives the number which the star has in Table D and in the C–M diagram. The sequences in the center area are listed first, then those for the outer variables within 8′ of arc, and finally approximate magnitudes for those variables lying near the edge of the plate for which no photovisual magnitudes were obtained.

3. ECLIPSING BINARIES

Table III lists the 54 variables of Field IV in order of discovery number. Explanations of the various columns are given at the bottom of the table. Among the variables are 10 eclipsing binaries, 6 of which have periods. The remaining 4 are faint, have small amplitudes, and no periods were derived; they are suspected eclipsing binaries because of their colors and because of few observations at minimum. The light curves of those with periods are given in Fig. 2.

V1, with a period of 511 days, has a color index at maximum of $-0^{\mathrm{m}}10$. Only 2 minima were observed; the first eclipse in 1953 lasted longer than 40 days, the second eclipse in 1957, which was observed on photovisual plates cannot have lasted longer than 100 days. In the figure the crosses represent the photovisual observations made brighter by $0^{\mathrm{m}}1$. The magnitudes of V1 are very uncertain as the star lies close to the plate edge, but part of the scatter is probably due to irregular variations at maximum. Its blue color and absolute magnitude of about -3.5 are not inconsistent with the spectral classes and luminosities found by Popper (1948) for binaries of similar period. The other binaries of Fig. 2 are mostly of the β Lyrae type, though V12 and V35 may be like Algol. V60 was discovered because it was originally used as a standard star. If it belongs to M31, its absolute magnitude is -6. V29 shows so much scatter compared to the other variables that the correct period may not have been found.

Table C lists the observations for the eclipsing variables. The first column is the Julian Day corrected for heliocentric time. The phase is computed using the reciprocal of the period (Table III) in the formula

$$\text{Phase} = 1/p(\text{JD of observation} - 2434000).$$

4. IRREGULAR VARIABLES

There are also 17 miscellaneous variables, mostly irregular giants. They are shown in Fig. 3 in order of their approximate colors. They have been plotted to show their type of variation from 1952 through 1956. The open circles represent single observations; the dots represent 2 or more observations on consecutive days. The first variable, V4, is the brightest of the red variables with a range greater than $1^{\mathrm{m}}0$. It may be cyclic or irregular, like μ Cephei. It appears to be the brightest star of a small association. The next 4 stars, with $B-V$ around $+2^{\mathrm{m}}0$, show small and slow changes from year to year, with rapid fluctuation superposed.

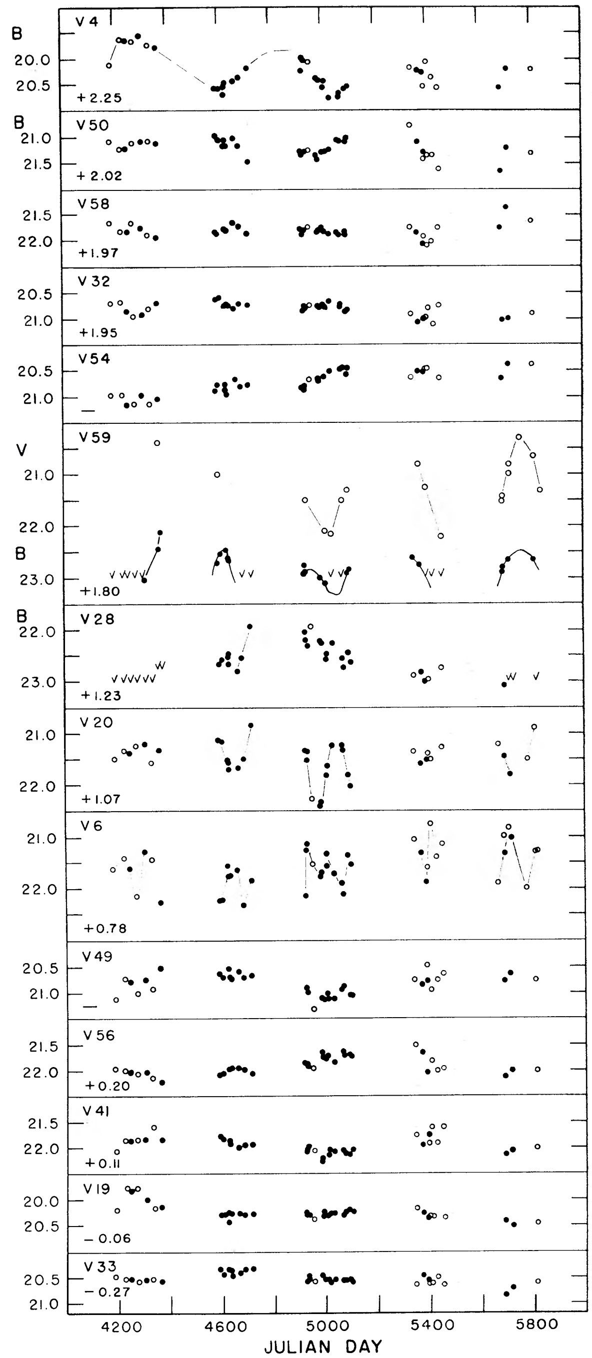

FIG. 3. Irregular variables in order of decreasing redness. Dots, mean of 2 or more consecutive observations; open circles, single observations, and for V59, photovisual observations.

Their mean characteristics are amplitude $=0^{\mathrm{m}}5$, $B-V=+2^{\mathrm{m}}0$, and mean $B=21^{\mathrm{m}}15$.

V59 is the only long-period variable that was found on the 103a-O plates. It was seldom seen and therefore fainter than $23^{\mathrm{m}}0$, and never observed at maximum in photographic light. On the photovisual plates it varies from $V=20^{\mathrm{m}}4$ to $22^{\mathrm{m}}3$. These observations are shown as open circles above the photographic obser-

TABLE IV. 20 Cepheids.

Var. No.	Period	Log P	B				V				B−V			
			Max.	Min.	Ampl.	Mag. of Mean$_I$	Max.	Min.	Ampl.	Mag. of Mean$_I$	Max.	Min.	Ampl.	Mag. of Mean$_I$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
15	21.263	1.328	19.78	21.40	1.62	20.68	19.31	20.28	0.97	19.80	0.45	1.20	0.75	0.95
31	13.336	1.125	20.08	20.82	0.74	20.46	19.57	20.07	.50	19.81	.52	0.80	.28	0.66
30	12.878	1.110	20.78	21.98	1.20	21.38	20.05	20.77	.72	20.38	.72	1.30	.58	1.05
5	12.840	1.109	20.69	21.97	1.28	21.32	19.94	20.68	.74	20.35	.65	1.35	.70	1.01
3	12.714	1.104	20.40	22.00	1.60	21.23	19.90	20.82	.92	20.38	.52	1.26	.74	0.91
8	9.643	0.984	20.60	21.70	1.10	21.08	20.10	20.70	.60	20.37	.50	1.06	.56	0.74
9	8.508	0.930	20.77	21.85	1.08	21.29	20.30	20.86	.56	20.55	.47	1.03	.56	0.76
17	6.732	0.828	21.22	22.34	1.12	21.82	20.50:	21.12:	.62	20.83:	.68:	1.20:	.52:	1.01:
2	4.368	0.640	21.18	22.34	1.16	21.80	20.75	21.55	.80	21.24	.42	0.80	.38	0.59
26	3.945	0.596	21.75	22.35	0.60	22.13	...	...	...	....	...	...	...	...
13	3.803	0.580	22.11	22.83	0.72	22.56	21.45	21.85	.40	21.72	.65	1.00	.35	0.86
46	3.711	0.569	22.62	23.30:	0.68:	23.07:	21.81	22.45:	.64:	22.15:	.75	1.10:	.35:	0.93:
36	3.593	0.555	22.05	22.89	0.84	22.51	21.50	21.95	.45	21.74	.55	1.05	.50	0.78
48	3.403	0.532	22.34	22.96:	0.62:	22.74:	21.90	22.10:	.20:	22.02:	.40	0.90:	.50:	0.73:
21	3.348	0.525	21.64	22.66	1.02	22.25	21.19	21.93	.74	21.64	.38	0.82	.44	0.63
42	3.098	0.491	21.63	22.25	0.62	22.00	...	...	...	...	...	...	...	...
10	3.043	0.483	21.81	22.55	0.74	22.29	21.30	21.90	.60	21.70	.47	0.71	.24	0.60
11	2.978	0.474	21.44	21.90	0.46	21.68	21.00	21.26	.26	21.09	.45	0.69	.24	0.59
27	2.593	0.414	21.85	22.69	0.84	22.37	21.38	21.86	0.48	21.68	0.50	0.92	0.42	0.71
16	2.514	0.400	22.20	22.80:	0.60:	22.55:	...	...	...	...	...	...	...	...

TABLE V. 7 "Population II" variables.

Var. No.	Period	Log P	B				V				B−V			
			Max.	Min.	Ampl.	Mag. of Mean$_I$	Max.	Min.	Ampl.	Mag. of Mean$_I$	Max.	Min.	Ampl.	Mag. of Mean$_I$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
34	62.0	1.792	20.95	21.71	0.76	21.33	20.33	20.81	0.48	20.59	0.55	0.95	0.40	0.75
57	53.5	1.728	21.86	22.20	0.34	22.04	21.18	21.42	.24	21.33	.60	0.86	.26	.70
24	46.25	1.665	21.00	21.80	0.80	21.37	20.45	20.80	.35	20.58	.60	1.00	.40	.80
25	39.43	1.596	21.75	22.83	1.08	22.14	...	...	...	...	...	...	...	...
22	37.30	1.572	21.45	22.71	1.26	21.96	21.05	21.70	.65	21.27	.40	1.00	.60	.74
53	19.87	1.298	22.35	22.99	0.64	22.63	...	...	...	...	...	...	...	...
55	19.26	1.285	22.40	23.15:	0.75:	22.74:	21.60	22.20:	0.60:	21.81:	0.70	1.15:	0.45:	0.93:

vations of V59 in Fig. 3. For the 5 years that it was observed it appears to have alternating high and low maxima. Its period is around 230 days.

The next 3 stars are semiregular. V28 has a $B-V=+1^{\rm m}.23$. It has a varying mean magnitude and may be similar to a variable like DF Cygni, though it should be observed for a longer time. V20 and V6 have cycles around 150 and 85 days, respectively, and $B-V$ of $+1^{\rm m}.07$ and $+0^{\rm m}.78$, but their variation is too irregular to obtain a mean light curve. It is possible that they might belong to the "Population II" variables that are discussed later. V49 with a range of $0^{\rm m}.5$ seems to vary from year to year. It is near the edge of the plates and no photovisual measures were made, but it seems to be neither red nor very blue.

The last 5 variables in Fig. 3 again have small amplitudes and slow variations. Their color indices are around zero. Of these, V19 is the only variable with distinct characteristics. In 1952 it was bright at $B=19^{\rm m}.80$, and slowly decreased in luminosity until in 1956 it was about $20^{\rm m}.4$. V19 lies in the brightest association of Field IV, as do the blue variable V33 and the red one, V32. The mean characteristics of the last 4 variables are amplitude$=0^{\rm m}.5$, $B-V=0^{\rm m}.0$, and mean $B=21^{\rm m}.4$.

Three variables have not been plotted. Their variation is probably short, and, if periodic, shorter than 4 days. They are V52, which is faint and near the edge of the field; V39, also faint; and V37, which lies near the bright association, has a small amplitude, and is rather blue in color.

5. CEPHEIDS

Table IV lists the Cepheid variables in order of decreasing period and gives more extensive information about magnitudes and colors than Table III. Columns 7, 11, and 15 list the magnitudes of mean intensity which were derived from magnitudes taken at 20 equal phase intervals along the light curve, converted to light intensities, and then the mean intensity converted back to magnitude. The $B-V$ magnitudes, columns 12 and 13, were also derived from the $B-V$ light curves and are not the same as column 7 minus column 11. The difference, due to different ways of deriving $B-V$, is greatest for those with greatest asymmetry.

Table A gives the photographic observations of Cepheids with the phase computed from the same formula as that used for the eclipsing stars. The number of the epoch from the initial Julian Day has been included. Table B for photovisual observations is similar to Table A, but when an observation is paired to a photographic plate taken just before or after it on the same night, the $B-V$ value is given. In a few cases when the observations occurred on a steep part of the curve, the photographic observation has been extrapolated to the time of the photovisual observation. No $B-V$ difference is given when V is fainter than $22^{m}10$, as the accidental error has increased and the $B-V$ value becomes almost meaningless.

Of the 20 Cepheids in Table IV, three (V16, V26, and V42) are close to the edge of the plates and their magnitudes are based on eye estimates of photographic plates only. V8 and V15 also lie closer to the plate edge than do their comparison stars, and are brighter than $B=21^{m}6$ at minimum. Since V15 has the longest period in the field and V8 has a period close to 10 days, an effort has been made to bring their magnitudes into the system of the other Cepheids. The eye estimates, though they are subject to larger accidental errors, are not as seriously affected by systematic errors; therefore, a correction curve formed from the differences between the iris photometer and eye measures plotted against the eye-estimated magnitudes was used to correct the photometer measures. It is these corrected values that are plotted in the figures and are given in Tables A and B. These corrected values agree with the magnitudes made on the few available offset plates.

The magnitudes of V48 seem uncertain because the variable is in a position on the 200-inch plates where the images break rapidly due to the edge of the Ross corrector. V46, close to the plate limit, suffers from bigger measuring errors. In measuring V17 on the photovisual plates, it was overlooked that there was a gap in the local sequence in V of some two magnitudes over the interval of variation of the star. This may cause an error in V of $\pm 0^{m}15$, which causes the error in $B-V$ to be exaggerated; hence the star has been omitted from any discussion of the relationships involving color.

The light curves of the 20 Cepheids are given in Figs. 4 through 8. The upper curves represent measures from the photographic plates, the middle ones show the photovisual observations, and the curves at the bottom are the $B-V$ differences. Single observations are plotted; the dots represent measures by the iris photometer and the open circles are from eye estimates. The lightly drawn B and V curves are derived from mean normal points. The curves for the $B-V$ observations are the differences for like phases of the mean B and V curves. This is because there are only 30 direct $B-V$ observations.

An intercomparison of the B and V amplitudes is shown in Fig. 9. This was done as a check on the relative correctness of the B and V scale of magnitudes, as most of the observations are fainter than $V=20$. A comparison of the photoelectric amplitudes of galactic Cepheids from lists of Eggen *et al.* (1957), Weaver *et al.* (1960), Irwin (1961), and Bahner *et al.* (1962) gives a slope of V amplitude$=0.65$ B amplitude, with a scatter of less than $\pm 0^{m}08$. Figure 9 shows the line of this slope and the scatter of the Field IV Cepheids around the curve. They fall for the most part within the allowable scatter, except for the faint variables, V46 and V48.

6. THE CEPHEID RELATIONSHIP OF PERIOD TO LUMINOSITY AND COLOR

The preceding section has discussed the variables as individuals; this section will examine the various relationships of the Cepheids. In Figs. 12 to 14, which show these relationships, the dots represent the classical Cepheids. The small open circles in Figs. 12 to 15 represent the mean of the Cepheids with periods over 8 days and those under 5 days. It is these mean points that are primarily used to fit the predicted relations.

The three sources of scatter around the mean curves of Figs. 12 to 14 are observational error, intrinsic differences in the variables, and differential absorption. The observational error increases with faintness of the magnitude and small errors in either or both B and V are magnified in $B-V$.

The second cause of scatter is the effect of the finite width of the instability gap, as predicted by Sandage (1958). Scatter due to this cause is shown by V31, a Cepheid of small amplitude and relative blueness which lies above the curve, while V3, of similar period with a large amplitude and redder, falls close to the mean P–L curve.

The third cause of scatter is differential reddening, which is so evident in two other fields of M31 (Baade and Swope 1955) and also apparent in Field II (Gaposchkin 1962); however, in this field with only 20 Cepheids and 96′ from the nucleus, the differential reddening has been ignored. This third cause of scatter will be further discussed in a later paper.

In Fig. 12(a) the straight-line period–luminosity curve is from Kraft's (1961) and Arp's (1960) equation $M_B=-1.33-2.25\log P$, shifted in magnitude to give the best fit. In Fig. 12(b) the photovisual P–L curve has been fitted in the same manner but the equation used is the mean of Kraft's and Arp's slopes:

$$M_V=-1.70-2.50\log P.$$

Figure 13 shows the period–color relation; the equation for the solid line is $B-V=+0.35+0.34\log P$, which was used instead of the quadratic equation given by Kraft (1961) for his mean relation for the galactic Cepheids corrected for reddening. Kraft had few Cepheids of long or short period and the equation for the straight line fits the segment between 2.5 and 25 days. The arrows indicate the dispersion of the galactic Cepheids about the mean curve. It is at once evident that the Cepheids in Andromeda are redder than the corrected galactic Cepheids. The dashed line represents the mean of the differences between the galactic relation and the observed colors of the Field IV Cepheids.

The mean color excess is $B-V=+0^{m}16\pm0.03$. The reddening for M31 expected from the cosecant law (Hubble 1934) is $+0^{m}15$, suggesting that most of the absorption is from our Galaxy and that little general reddening is due to Andromeda itself. This observational finding is not too surprising, as Stebbins and

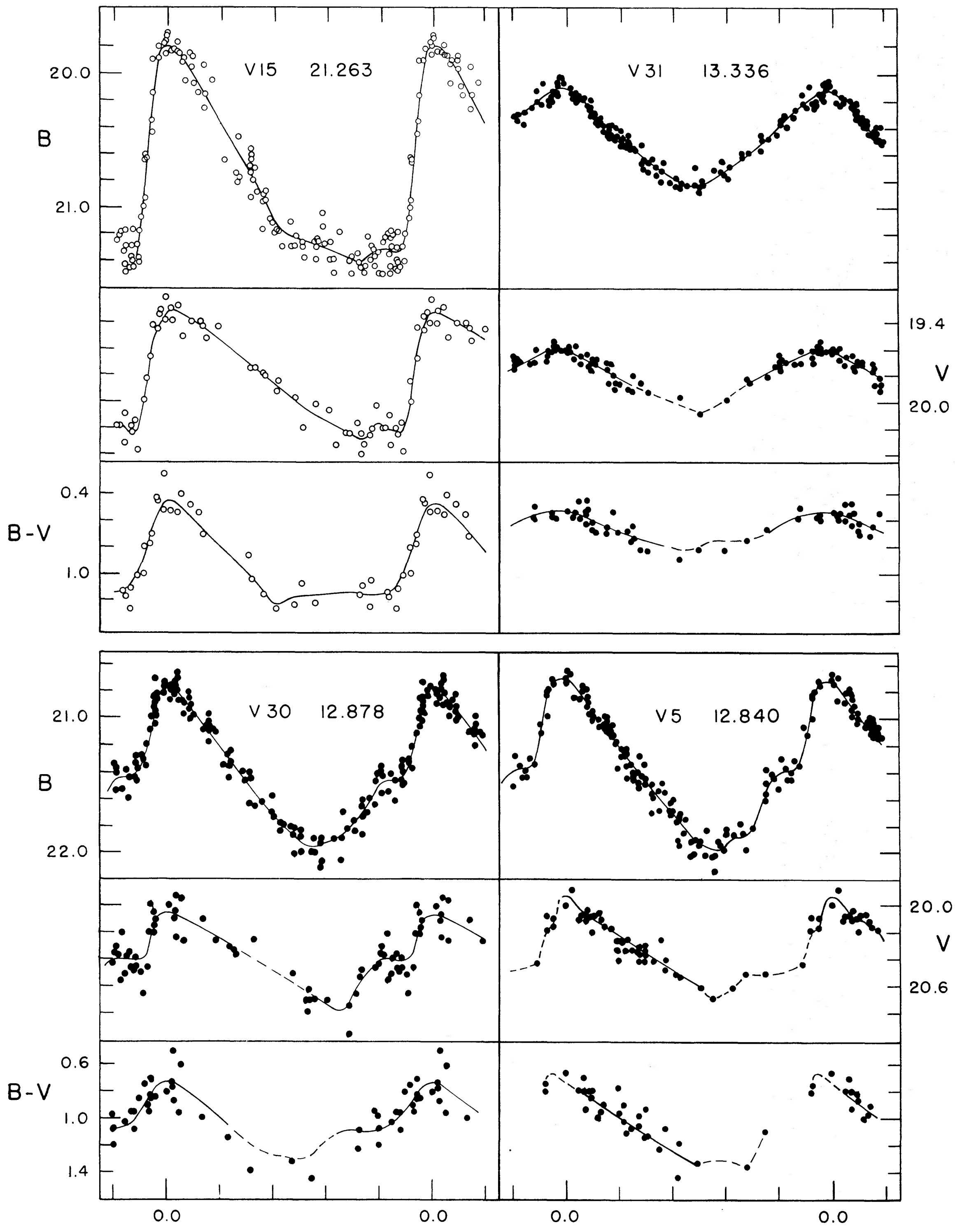

FIG. 4. Cepheids. Dots, iris photometer measures; open circles, eye estimates.

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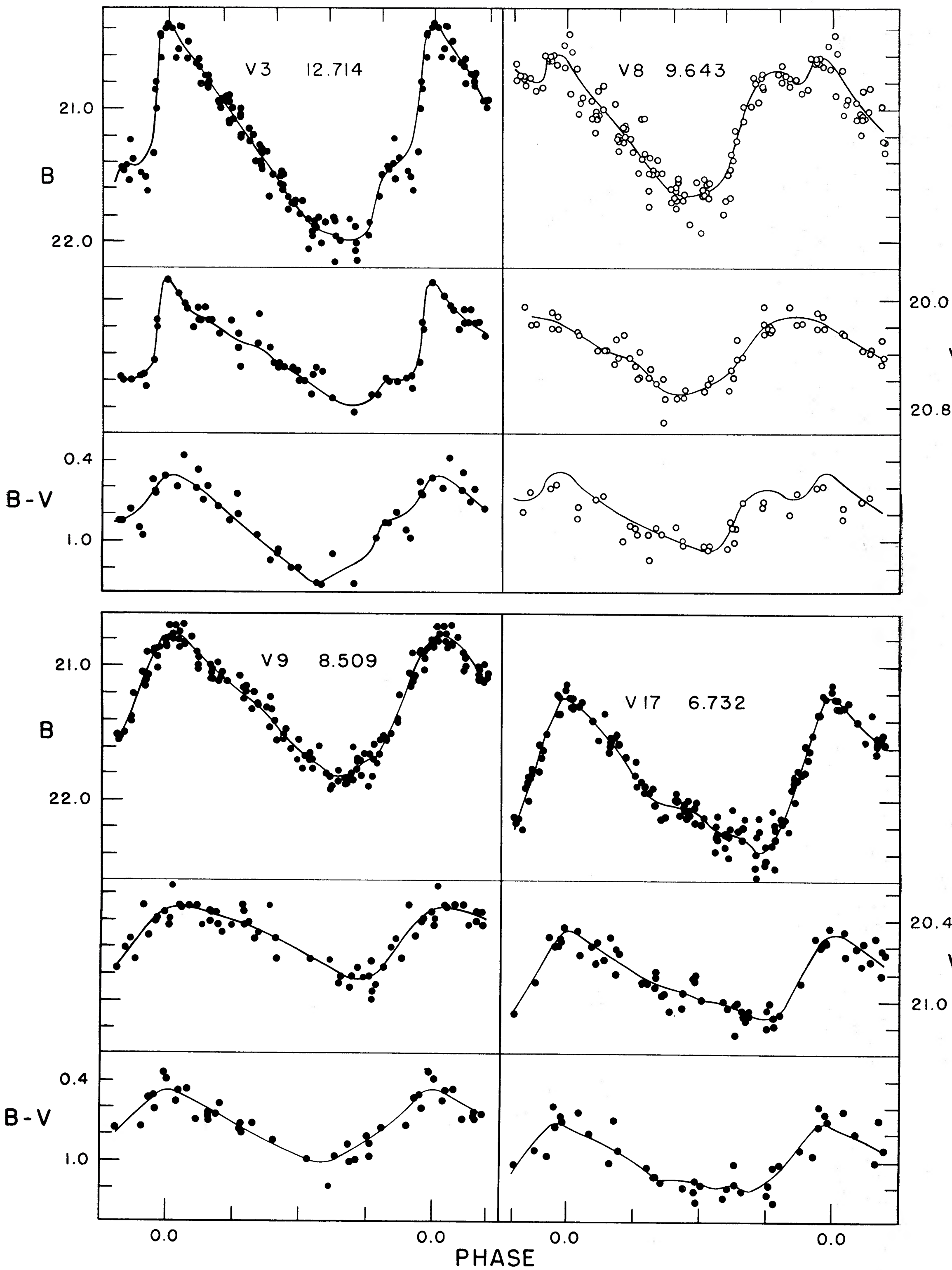


FIG. 5. Cepheids. Dots, iris photometer measures; open circles, eye estimates.

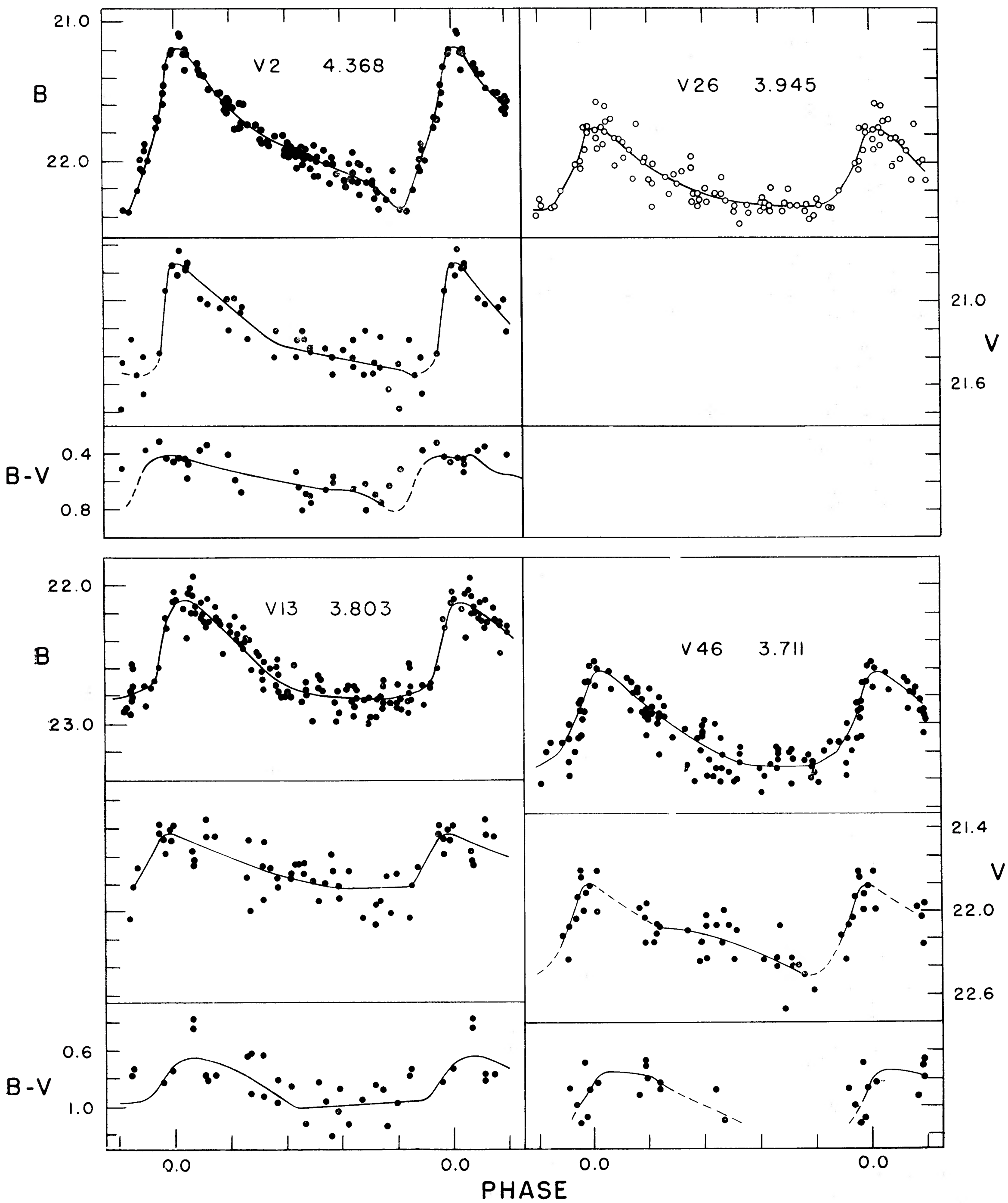


FIG. 6. Cepheids. Dots, iris photometer measures; open circles, eye estimates.

Whitford (1934) had estimated that the sun's relative position in M31, based on surface luminosities, would be about 1° from the nucleus. Field IV, 1°.6 from the nucleus, is more than 60% farther out and, therefore, less absorption may be expected than is observed in the neighborhood of the sun. Van der Hulst, Raimond, and van Worden (1957) also found that in M31, at 1°.5 out from the nucleus on the southwest axis, very little hydrogen was observed.

7. DISTANCE

Having seen that the slope of the P–L relationship for Andromeda is similar to that for our Galaxy and the Small Magellanic Cloud, and having determined the average color excess, the distance to Andromeda can be obtained. The apparent modulus for each Cepheid in both B and V was found from the equations for absolute magnitude and the magnitudes of mean intensity from Table IV. For 20 Cepheids the mean apparent modulus in B is $24^{\rm m}.84$, with a mean error of $\pm 0^{\rm m}.08$, and for 17 Cepheids the modulus in V is $24^{\rm m}.68 \pm 0.07$ m.e. Correcting for the mean reddening of $+0^{\rm m}.16 \pm 0.03$, the unreddened modulus for both B and V is $24^{\rm m}.20 \pm 0^{\rm m}.14$. The distance to Andromeda is 692 ± 50 kpc, and the distance of the sixth spiral arm is 19 300 pc south preceding the nucleus of M31.

The internal error from the material of M31 is around 10%, but there are also errors due to the uncertainties in the fundamental sequences of M31 and to the uncertainties still remaining in the galactic standards, such as the estimated reddening for the galactic Cepheids. The slope of the P–L curve might also be changed if Cepheids of longer and shorter periods would be photoelectrically observed. These could double the mean error. There is also the question whether Cepheids in the Andromeda galaxy are the same as galactic Cepheids. So far the evidence indicates that they are very like the galactic Cepheids, but that

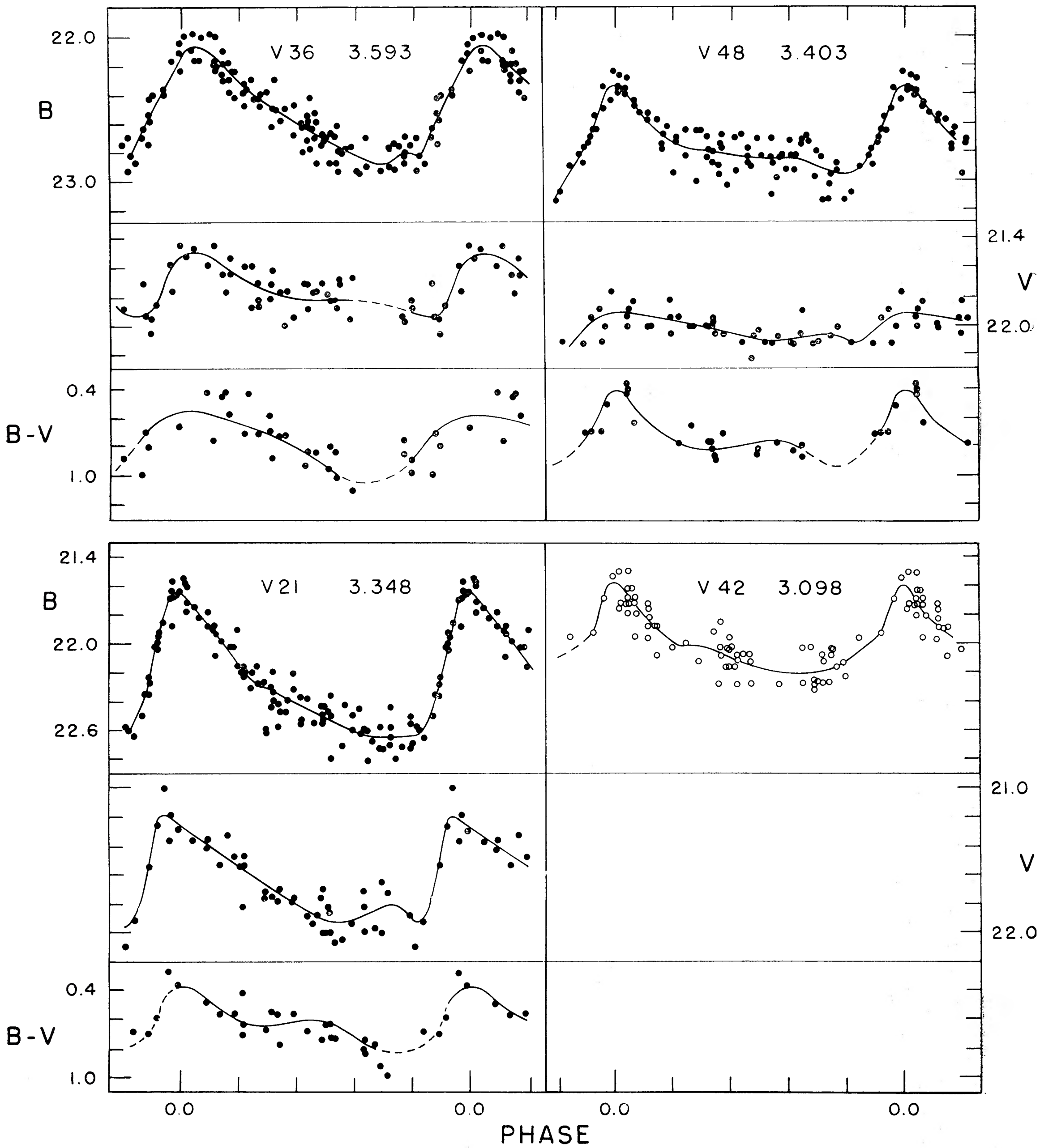


FIG. 7. Cepheids. Dots, iris photometer measures; open circles, eye estimates.

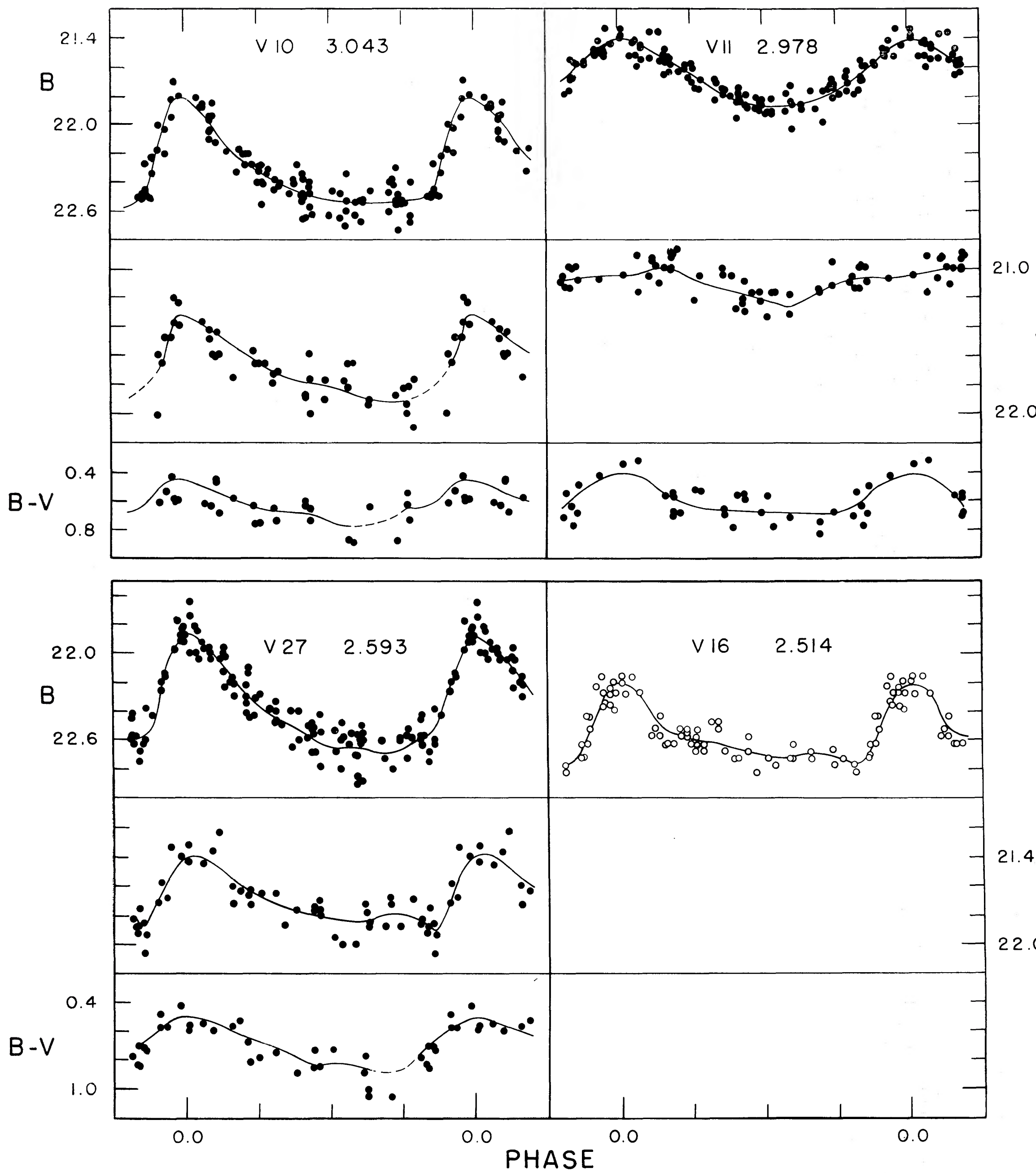


FIG. 8. Cepheids. Dots, iris photometer measures; open circles, eye estimates.

there may be differences between the Cepheids of these two galaxies and the Magellanic Cloud Cepheids. The Large Cloud apparently has a steeper P–L slope (Woolley *et al.* 1962), and both Clouds have many large-amplitude Cepheids with periods less than 5 days, which is contrary to what has been found so far in M31 and the Milky Way system.

8. INSTABILITY GAP

Figure 14 shows the distribution of the Cepheids across the instability gap of the C–M diagram; the symbols are described in Sec. 6. The variables have been plotted using the left-hand and bottom coordinates corresponding to apparent V and $B-V$. The lines that are shown have been plotted using the right-hand ordinate of absolute magnitudes and the top abscissa, which is $B-V$ corrected for reddening. The vertical line is the computed relation for galactic Cepheids from the equations for period, luminosity, and color (Sandage 1958; Kraft 1961), and the cross lines are the lines of constant period. The M31 and galactic Cepheids

TABLE VI. Absolute magnitudes of Cepheids and Population II variables in Field IV, M31.

Var.	Log P	M_B	M_V
15	1.328	−4.16	−4.88
31	1.125	−4.38	−4.87
30	1.110	−3.46	−4.30
5	1.109	−3.52	−4.33
3	1.104	−3.61	−4.30
8	0.984	−3.76	−4.31
9	.930	−3.55	−4.13
17	.828	−3.02	−3.81:
2	.640	−3.04	−3.44
26	.596	−2.71	...
13	.580	−2.28	−2.96
46	.569	−1.77:	−2.53:
36	.555	−2.33	−2.94
48	.532	−2.10:	−2.66:
21	.525	−2.59	−3.04
42	.491	−2.84	...
10	.483	−2.55	−2.98
11	.474	−3.16	−3.59
27	.414	−2.47	−3.00
16	0.400	−2.29:	...
34	1.792	−3.51	−4.09
57	1.728	−2.80	−3.35
24	1.665	−3.47	−4.10
25	1.596	−2.70	...
22	1.572	−2.88	−3.41
53	1.298	−2.21	...
55	1.285	−2.10:	−2.87:

appear to have similar luminosities and colors for the same period.

The other Cepheid relationships, such as amplitude, asymmetry, and frequency, that do not involve color have been left to a later paper when the more numerous Cepheids of Fields I and III will be discussed.

9. POPULATION II VARIABLES

There are 7 variables in Field IV with periods between 19 and 62 days. In Table III they have been listed as semiregular, RV Tauri, and W Virginis type variables. There seems to be a relation between their length of period and brightness. However, compared with the Cepheids of Table IV, they are less regular in period, they have a larger magnitude scatter around the mean light curves, and for corresponding periods they are about two magnitudes fainter. Particularly for this last reason, and for the convenience of a general term, they have been called "Population II" variables in the rest of this paper. Because their characteristics are so varied, the designation "Type II" Cepheids seemed inappropriate as it expressed too limited a term. These 7 variables are listed in Table V. It is similar to Table IV, which was described in Sec. 5. The individual observations are included in Tables A and B.

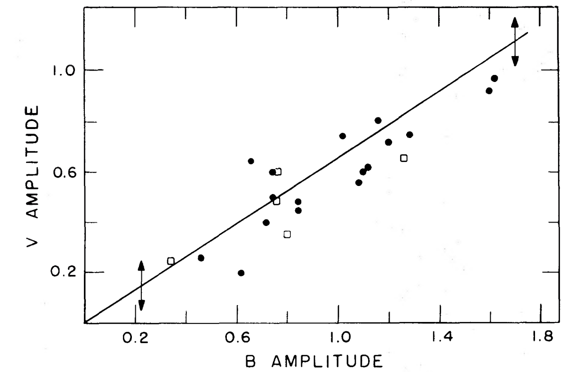


FIG. 9. Comparison of B and V amplitudes. Dots, Cepheids of Table IV; open squares, variables of Table V. Line is B and V amplitude relation of galactic Cepheids and arrows show dispersion.

V34, V57, and V24 (Fig. 10) have periods between 46 and 62 days, with small amplitudes. V57 shows a great deal of scatter, which may be caused by the wrong period or the measures may suffer from the same troubles as do those for V48 (Sec. 5). V34, which because of a close companion was estimated by eye only, seems fairly regular for the 6 yr observed. V24 has been treated as if it had a constant period but occasionally the time of maximum shifted. The lower curves on the left in Fig. 10 are the observations of V24 in 1952, 1953, and 1957. The lower curves on the right are for 1954, 1955, and 1956. The first observed shift was around JD 2434700, so the last 3 observations of 1953 are plotted in the light curve on the right-hand

TABLE VII. Absolute magnitudes for globular-cluster variables in the Milky Way system with periods over one day.

Globular Cluster Variables		Log P	Apparent Magnitude* m−M	Apparent Magnitude* V	Apparent Magnitude* B−V	Cosecant Reddening	Corrected for Reddening $(m-M)_0$	Corrected for Reddening V_0	Corrected for Reddening $(B-V)_0$	Absolute Magnitude (RR Lyr Var.+ 0.45) m−M	Absolute Magnitude (RR Lyr Var.+ 0.45) M_V
M2	11	1.53	16.1	12.23	0.57	0.10	15.80	11.93	0.47	15.35	−3.42
	6	1.29		13.03	.67			12.73	.57		−2.62
	5	1.25		13.24	.65			12.94	.55		−2.41
	1	1.19		13.39	.63			13.09	.53		−2.26
M3	154	1.18	15.6	12.32	.53	0.06	15.42	12.14	.47	14.97	−2.83
M5	84	1.42	15.0	11.36	.61	0.08	14.76	11.12	.53	14.31	−3.19
	42	1.41		11.31	.57			11.07	.49		−3.24
M10	2	1.27	14.7	11.83	.82	0.17	14.19	11.32	.65	13.74	−2.42
	3	0.90		12.76	.76			12.25	.59		−1.49
M13	2	0.71	14.6	12.78	.59	0.09	14.33	12.51	.50	13.88	−1.37
	6	0.33		13.85	.63			13.58	.54		−0.30
	1	0.16		13.69	.52			13.42	.43		−0.46
M15	1	0.16	15.8	14.89	0.33	0.12	15.44	14.53	0.21	14.99	−0.46

*Arp's (1955) magnitudes adjusted to B, V system.

side. The last 3 observations of 1955 seem to fit better on the light curves on the left-hand side. Though V24 is unstable, it does not have the deep and shallow minimum typical of RV Tauri-type variables.

In Fig. 11 V25 and V53, both near the edge of the plate, were estimated by eye and on photographic plates only. V22 and V25 have characteristic RV Tauri-type light curves. The double periods have been plotted in Fig. 11; however, the single periods are given in the table, are used to compute phases, and have been plotted in the graphs showing relationships. V25 has varied fairly regularly for the five years observed. V22 has shifted the time of its deep minima. This happened in 1955 and in 1957; they have been plotted in Fig. 11 as open circles, but shifted by one-half period.

The last 2 variables, V53 and V55, are both faint and have similar light curves. They are probably W Virginis-type variables.

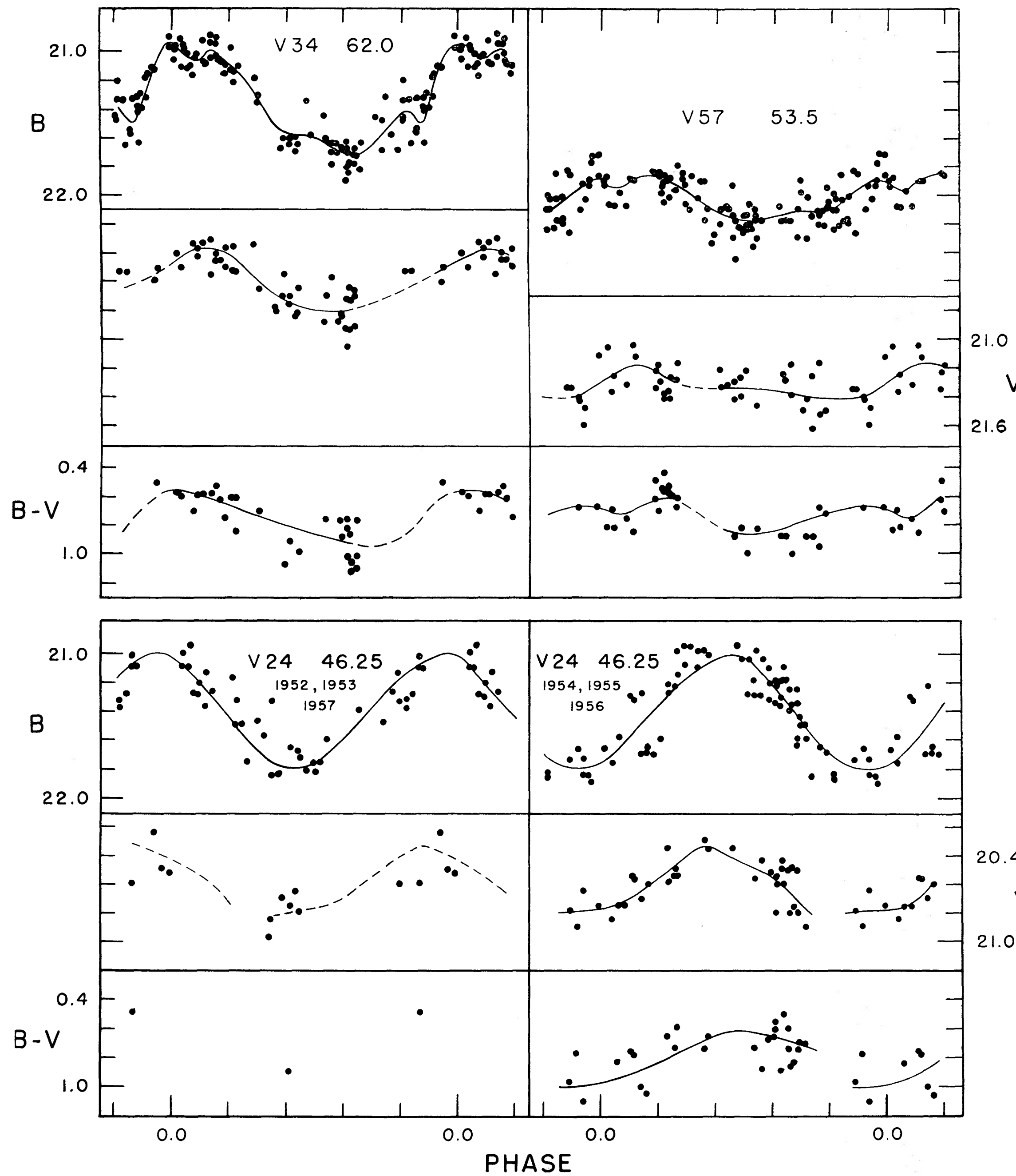


FIG. 10. "Population II" variables or semiregular variables. For V24, which shifted time of maximum, light curves on lower left represent observations in 1952, 1953, and 1957; those on lower right, observations of 1954, 1955, and 1956. For V34, only eye estimates because of close companion.

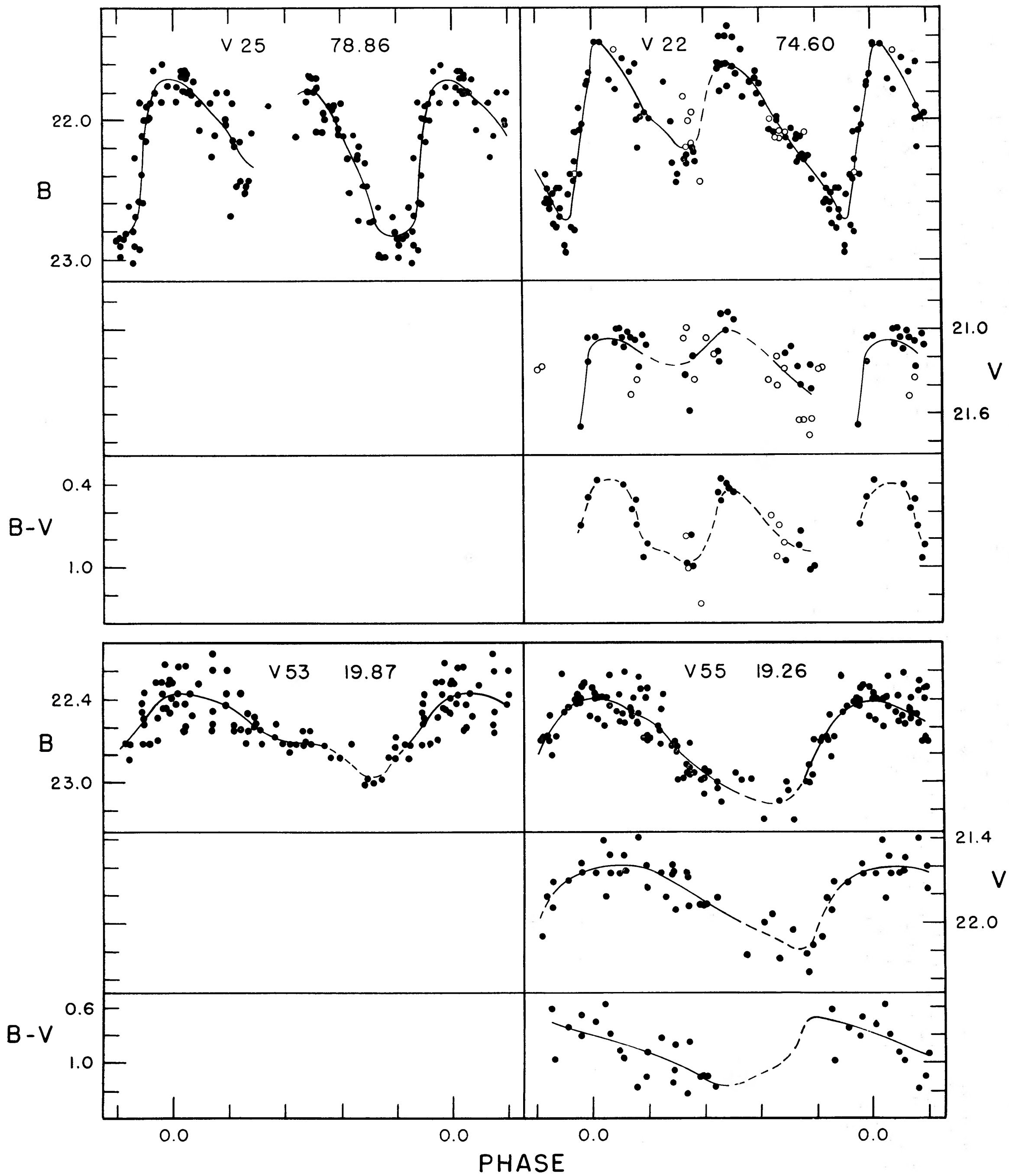
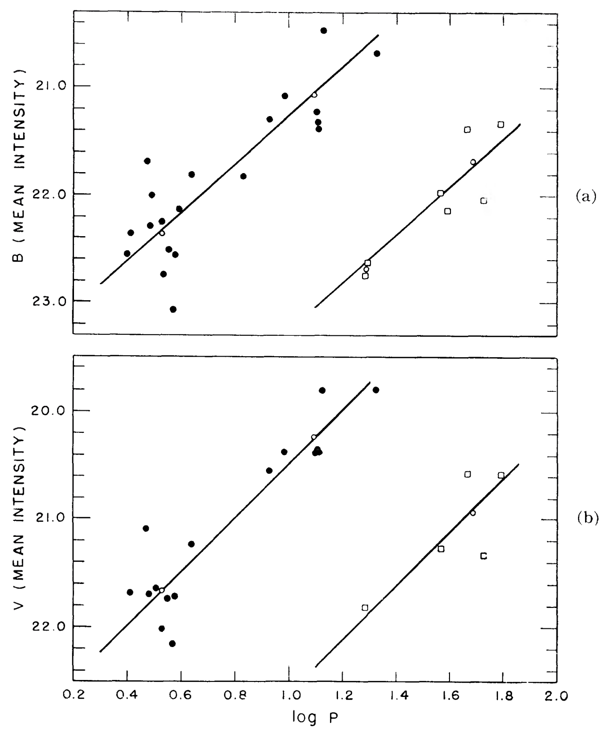


FIG. 11. "Population II" variables. Two RV Tauri and two W Virginis-type variables. V25 and V53 are eye estimates. Check marks indicate observations below plate limit; open circles in V22 are observations of 1955 and 1957 shifted by one-half period.



FIGS. 12(a) and 12(b). Period-luminosity relation in *B* and *V*, respectively. Dots, Cepheids; open squares, Population II variables; small open circles, mean points.

10. RELATION OF THE POPULATION II VARIABLES TO THE CLASSICAL CEPHEIDS

In Figs. 12 through 15 the Population II variables of Table V are plotted as open squares. The small open circle is the mean of the variables with periods over 35 days. The P–L slope for the Population II Cepheids has been drawn parallel to that determined for the Cepheids of Population I. It was not possible to make an independent determination of slope as the Population II variables are too few and have too limited a range of period. The parallel curves were shifted up and down to find the best separation between the two classes of variables. For the photographic observations [Fig. 12(a)] the separation is about $2^{m}.00$; for the photovisual curves [Fig. 12(b)] the Population II variables are $2^{m}.15$ fainter. In Fig. 13 the Population II variables are bluer than would be expected for the colors of Cepheids with periods of equal length. This blueness is also characteristic of W Virginis-type variables found in globular clusters. Though there is no diagram for the period–amplitude relation in this paper, for their length of period these variables seem to have rather smaller amplitudes than regular Cepheids of like periods.

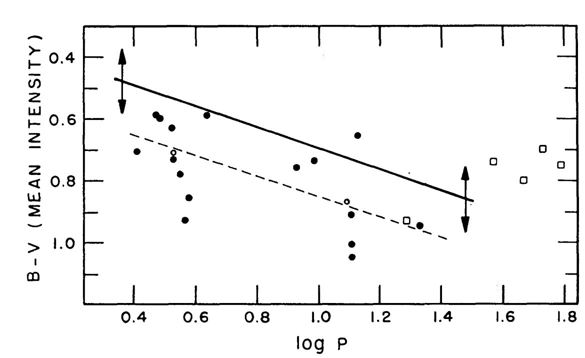


FIG. 13. Period–color relation. Symbols are the same as in Fig. 12. Solid line is the P–C relation for galactic Cepheids and arrows show the dispersion. Dashed line indicates the average reddening of $0^{m}.16$ for M31 Cepheids.

In Fig. 14 the Population II variables also fall in the instability gap. However, the displacement between the periods of a Cepheid and a Population II variable

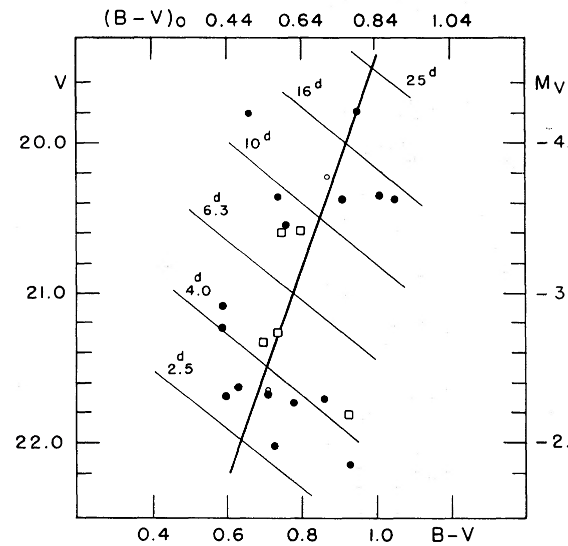


FIG. 14. Instability gap. Symbols are the same as in Fig. 12. Left-hand and bottom coordinates are apparent V and $B-V$; right-hand and top coordinates are absolute M_V and $B-V$ corrected for reddening. Vertical line is Kraft's (1961) luminosity–color relation for galactic Cepheids and cross lines show the period grid for Cepheids. For periods for Population II variables, see Sec. 10.

of the same luminosity and color is derived from Fig. 12, and the relation between periods of the same luminosity is given by

$$\log P_{\rm II} = \log P_{\rm I} + 0.8,$$

where $P_{\rm I}$ and $P_{\rm II}$ are the periods of the Cepheids and Population II variables, respectively.

11. POPULATION II VARIABLES OF M31 AND GLOBULAR CLUSTER VARIABLES WITH PERIODS GREATER THAN ONE DAY

It is apparent that these 7 variables of Table V form a sequence in P–L and P–C relationships which are displaced from those observed for the classical Cepheids.

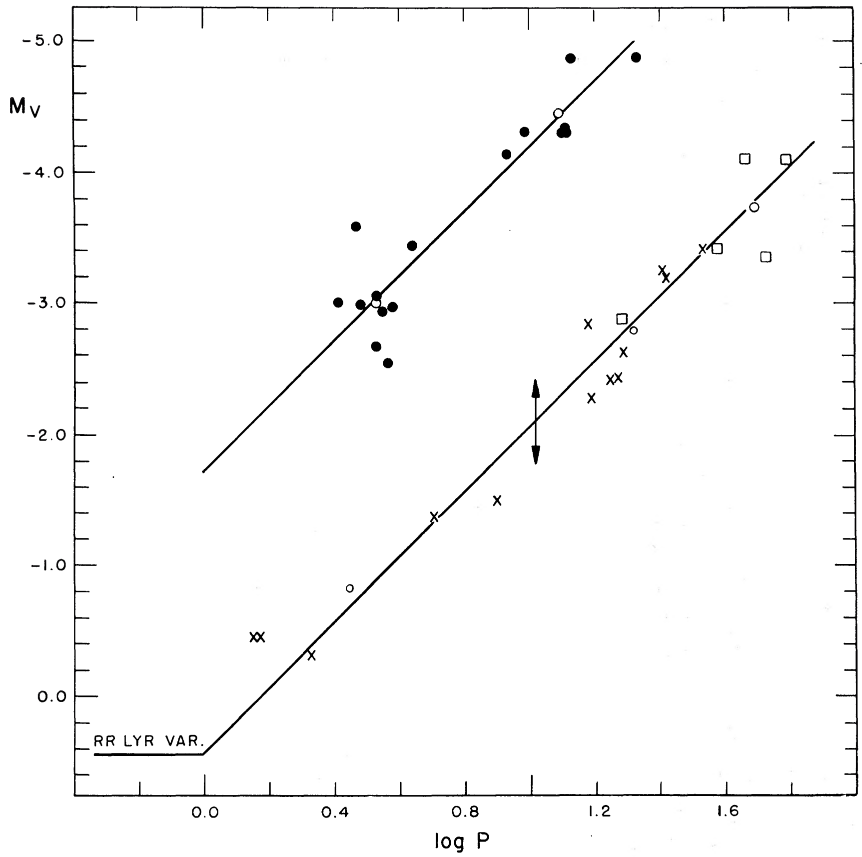


FIG. 15. Period–luminosity relation. Dots and open squares, Cepheids and Population II variables in M31, respectively; crosses, variables with $P>1$ day in Milky Way globular clusters; small open circles are mean values. Coordinates are visual absolute magnitude M_V and $\log P$. Upper line is $M_V = -1.70 - 2.50 \log P$; lower line is $M_V = +0.45 - 2.50 \log P$.

This gives weight to the idea that they do not lie in the spiral arms but may really belong to the disk population. With both classical Cepheids and "Population II" variables found in M31, it is tempting to try to see whether the W Virginis stars of the Milky Way globular clusters can be fitted to them. For this purpose the absolute magnitudes for the variables of Field IV are listed in Table VI and are plotted as dots and open squares in Fig. 15. Table VII lists the variables with periods greater than a day found in globular clusters of our Milky Way system. The table is based on Arp's material (1955a,b) with the magnitudes adjusted to the B, V system and corrected for cosecant reddening (Arp 1962).

In determining the distance moduli of the clusters, it has been assumed that the absolute magnitudes of the RR Lyrae stars are the same for all systems. An arbitrary zero absolute magnitude was first chosen and the M_V's of the variables were plotted against $\log P$. This graph was then fitted to the Population II variables of Fig. 15 by keeping $\log P$ the same and shifting the magnitudes up and down. There is very little overlap between the periods of the globular-cluster variables and those of Population II in Field IV, but the best, though tentative, fit indicates that the absolute magnitude of the RR Lyrae variables is between $0^{m}.4$ and $0^{m}.5$.

It is probably a coincidence that when the straight line through the Population II variables—drawn parallel to the classical Cepheids—is extended, it passes through $M_V = 0.45$ at $\log P = 0$. It was from these two not completely independent methods that $M_V = +0^{m}.45$ was derived as the absolute magnitude of the globular-cluster RR Lyrae stars. This value was used to compute the absolute magnitudes of the globular-cluster variables with periods over 1 day that are given in the last column of Table VII and are plotted as crosses in Fig. 15. The equation for the extended line, $M_V = +0^{m}.45 - 2^{m}.50 \log P$, gives a slope that fits as well as any for the limited material now available. The classical Cepheids and the Population II variables of M31 and the W Virginis Cepheids of the globular clusters all give the same mean scatter of $\pm 0^{m}.23$ around the P–L slopes, as they are drawn in Fig. 15.

Since the number of variables considered is small, it is not yet possible to say whether the P–L relation for the Population II variables is definitely parallel to that for the classical Cepheids and the luminosity difference is constant, or whether there should be a different slope, or even whether there should be a curvature in the P–L slope of one or both kinds of variables. However, the material does show that for the variables with periods longer than 16 days the difference between the two populations is $V = 2^{m}.15$.

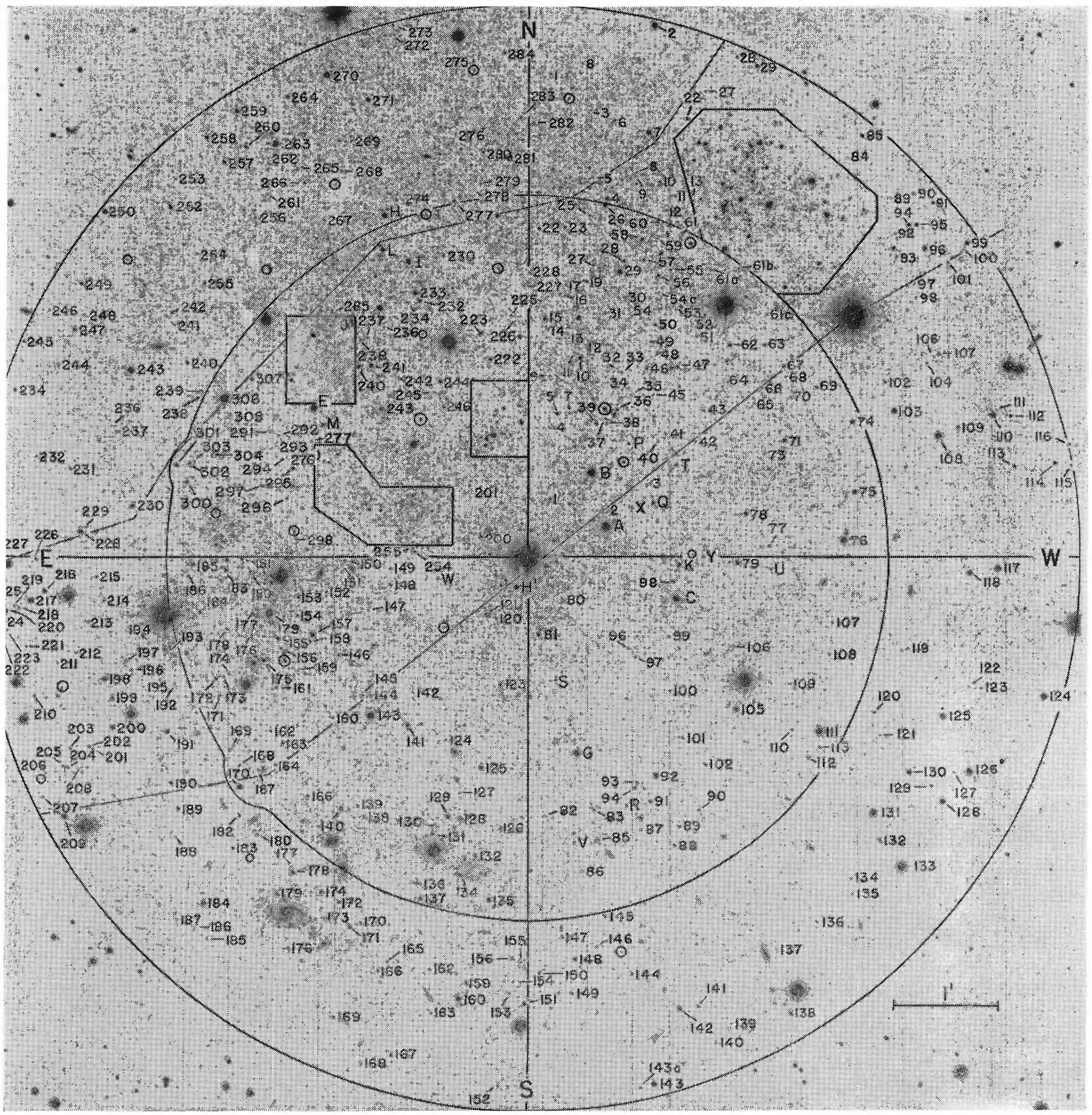


PLATE III. Enlargement of a 200-inch photovisual plate of central area showing stars measured for the color–magnitude diagram. Region of spiral arm indicated.

12. C–M DIAGRAM

Baade's Field IV is the only field in Andromeda for which a color–magnitude diagram has been attempted, for it is the only field of the four where the star images are not too crowded and there is no bright background to affect the measurements in the iris photometer.

TABLE VIII. Plates measured for color–magnitude diagram.

Plate	Emulsion, Filter	Exposure
PS 1463-B	103a-D + GG 13	30^m
1477	" "	30
1488	" "	30
PS 1140-B	103a-D + GG 11	90
1462	" "	60
1505	" "	60

Plate III shows the area that was measured. It has a radius of 5.′2 and covers about 85 square minutes of arc. It is the area in which no correction for distance from plate center has had to be made. Plates IV and V are enlargements of the associations that are seen in the spiral arms. The photometry for the color–magnitude diagram was done on the six plates listed in Table VIII, All stars that are free standing, fainter than $V=15^m_.0$. and brighter than $V=22^m_.0$ have been measured. The B limit is $23^m_.0$, and about 69 stars were measured that

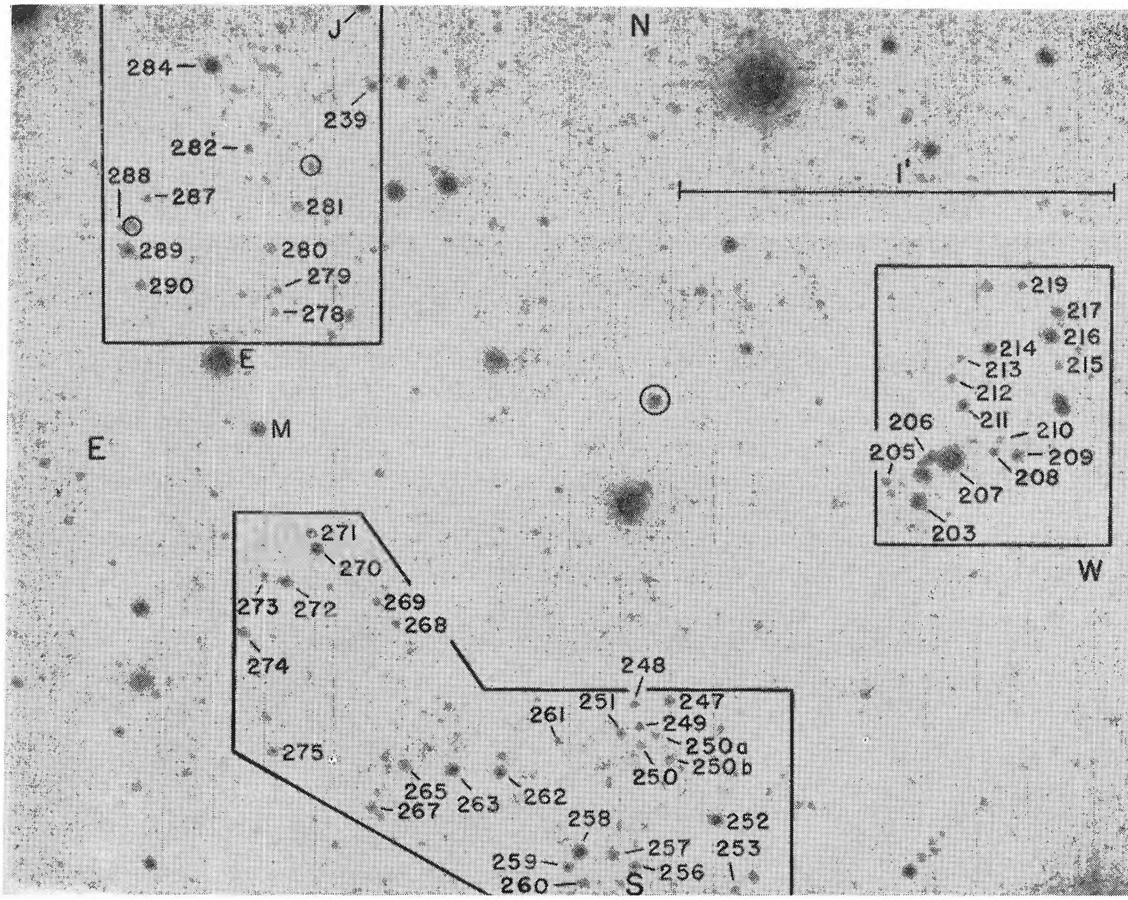


PLATE IV. Three small associations in spiral arm, with stars measured for C–M diagram marked.

are fainter than $B=22^m.0$ but have no photovisual magnitudes. As the selection of stars was made primarily on the 103a-O plates, there is not a good count of stars that are redder than $B-V=+1^m.4$ and between $V=21$ and 22 mag., but which would be fainter than $23^m.0$ on the photographic plates.

The color–magnitude diagram of Fig. 16 shows all the stars of Table D and the standard-sequence stars of Table I. It is evidently a combination of stars of M31 and foreground stars. To try to disentangle which stars belong to which system, a star count was made on a 48-inch Schmidt plate (PS 2474, 103a-D, amber filter

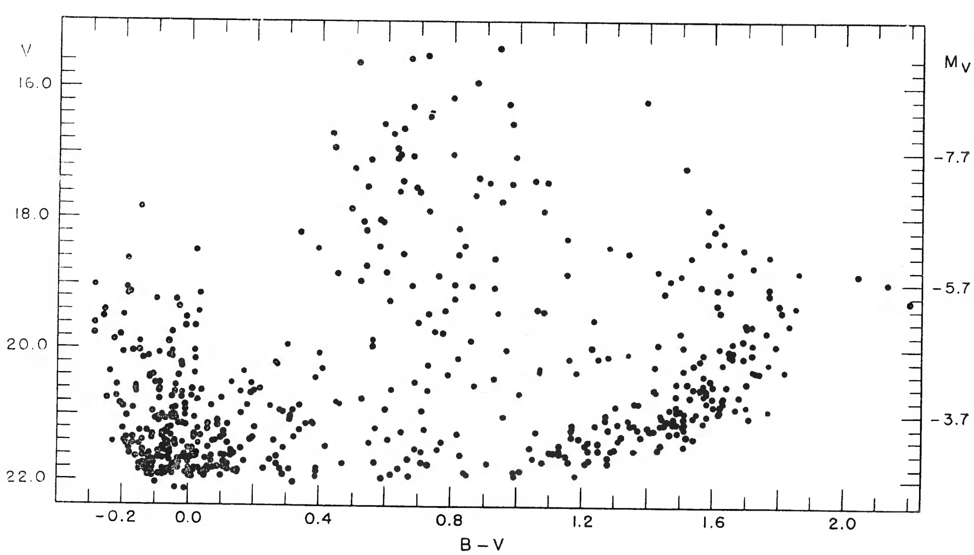


FIG. 16. Color–magnitude diagram for Field IV, M31. Includes the 566 stars of Table D and Table I.

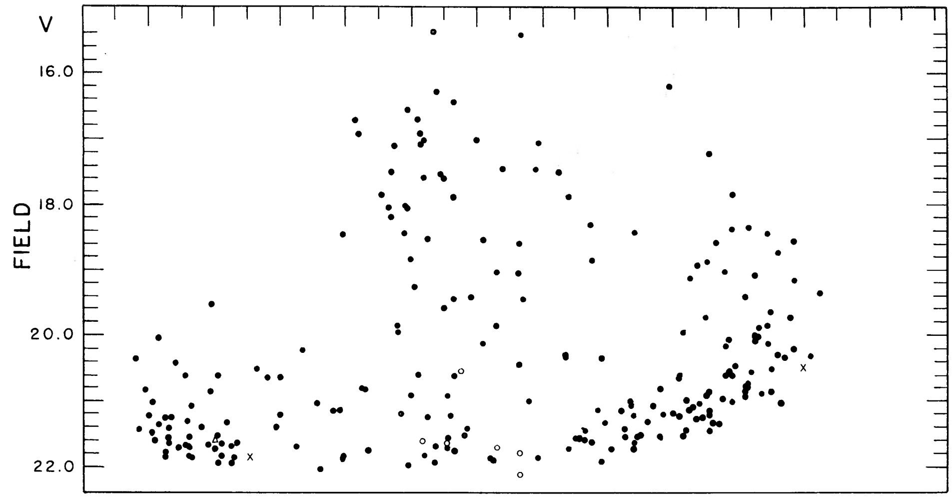


FIG. 17. Color–magnitude diagram of 222 stars outside apparent spiral arm in C–M area. Symbols for variables are: open circles, cepheids and Population II variables; triangles, eclipsing stars; crosses, irregular variables.

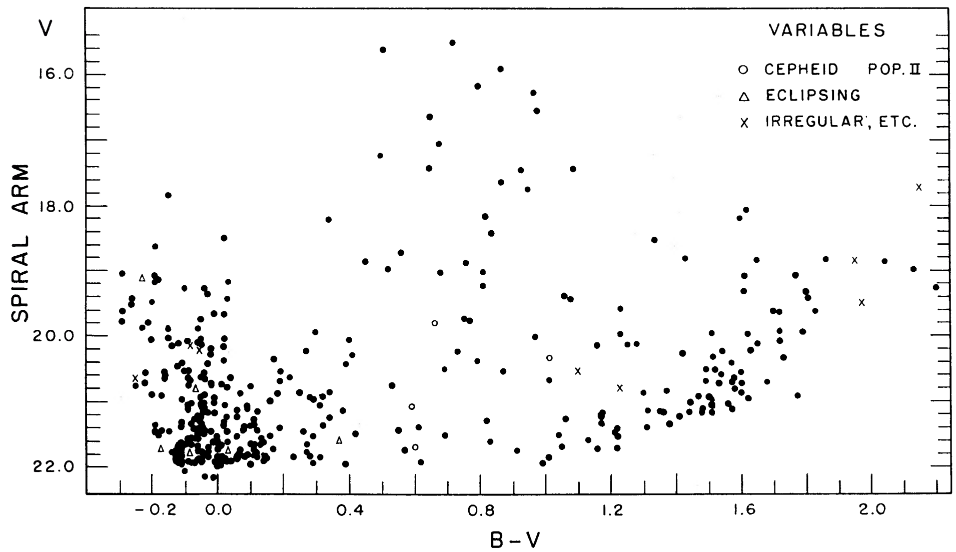


FIG. 18. Color–magnitude diagram of 344 stars in spiral arm as outlined in Plate III. Symbols for variables are the same as in Fig. 17.

and 20-min exposure). An area was counted that was nine times the size of that for the C–M diagram, on a field 1°.5 of arc following Field IV, and located on the same relative part of the 48-inch plate as Field IV.

Field IV was also counted as a check, and the count seemed reasonably close to the count from the C–M diagram. Therefore, in the following discussion, the number of stars for Field IV are taken from the C–M measures.

The stars on the Schmidt plate were counted from $V=15^{m}.0$ to about the plate limit of $V=19^{m}.7\pm0.1$. For the check field it gave an average of 85 ± 9 stars for an area equal in size to the C–M area in Field IV. In Fig. 16 there are 106 stars redder than $+0^{m}.2$ and brighter than $V=19^{m}.7$. These limits exclude the main-sequence stars of M31 and should correspond to the colors of the stars counted in the outside area. The count indicates that at least 80% of the stars brighter than $19^{m}.7$ and redder than $0^{m}.2$ are probable foreground stars, and that there is a fifty–fifty chance that from 0 to 20% of the stars may be members of M31.

The approximate outline of the sixth spiral arm is shown in Plate III. It is defined by the greater frequency of stars and by the associations. The stars outside this arm have been called "field stars" and are plotted in Fig. 17. They show the faint beginning of the main sequence and the upper part of the giant branch of M31. The frequency of stars brighter than $19^{m}.7$ is about that found for the outside area counted on the Schmidt plate; therefore it is assumed that most of them belong to the foreground and are members of our Galaxy. In Fig. 18 the distribution of the stars in the spiral arms and the associations are shown. The strength of the main sequence is pronounced. The stars that are brighter than $19^{m}.7$ and redder than $+0^{m}.2$ are more frequent per unit area than they are in Fig. 17, indicating that about $15^{\pm}$ stars belong to M31, and of these about half are in the giant branch—particularly the stars that have $B-V=+1^{m}.8$ and are redder than any in Fig. 17.

Figure 19 shows the distribution of stars in the three small associations, as shown on Plate IV, and Fig. 20

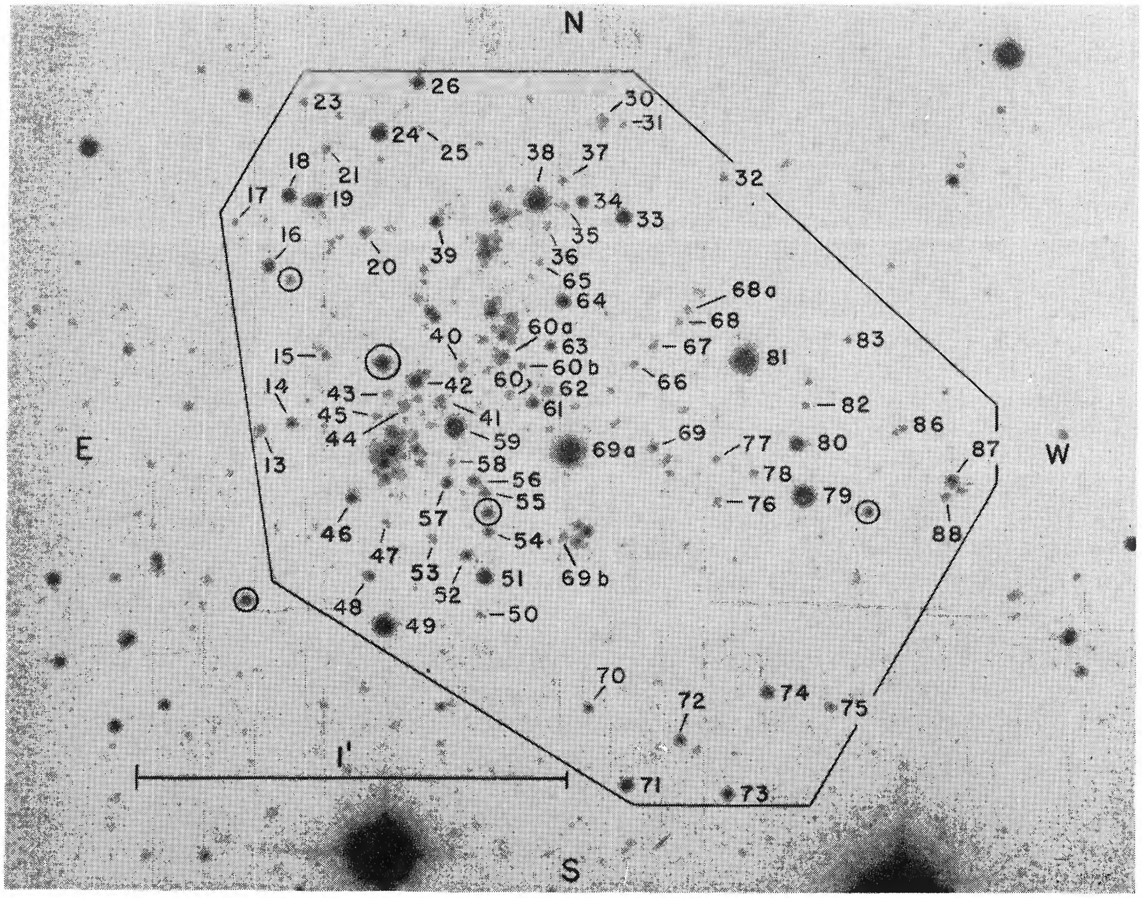


PLATE V. Big association in spiral arm, with stars measured for C–M diagram marked.

shows the stars in the big, bright association of Plate V. The two figures are similar, but, since the features are more clearly defined in Fig. 20, it has been used as the basis of the following discussion. The main sequence of the bright association can be fitted to the main sequence of h and χ Persei (Sandage 1957) by shifting M31 blueward by about $0^{\mathrm{m}}.16$, which is the same reddening as found for the Cepheids from the period–color relation (Sec. 6). The two brightest stars in the main sequence have absolute magnitudes between -6 and -7, which is also like the brightest main sequence stars of h and χ Persei (Johnson and Hiltner 1956).

Another feature of Fig. 20 is that there are 5 stars clustered around the 17th magnitude with colors about $+0^{\mathrm{m}}.8$, and that there are no other stars between the main sequence and the giant branch. An inspection of Fig. 17 of the number of stars brighter than $19^{\mathrm{m}}.7$ and redder than $+0^{\mathrm{m}}.2$ shows that only one star should be expected in an area the size of the big association; therefore, it possibly suggests that from two to four of these bright stars in Fig. 20 are real members of M31 and do not belong to the foreground. This means that they may be G and K supergiants in the big cluster with absolute magnitudes about $-7^{\circ}.5$.

The positions of the variable stars have been indicated in Figs. 17 and 18, the C–M diagrams for the field and spiral arms, respectively. The different kinds of variables are shown with different symbols. It is interesting to note that there does not seem to be a concentration of Cepheids within the apparent spiral arm. Of the 20 Cepheids in Field IV, only 8 lie within the C–M diagram area, and of these only 4 are within the outlined spiral arm. This distribution may differ from that found in the fields closer to the Andromeda nucleus and may be related to period length, but this matter will be discussed in greater detail in a later paper. The Population II variables all lie outside the spiral arm. The eclipsing binaries and irregular variables seem to occur more frequently per number of stars involved within the arms rather than outside, but the variables are few and no definite conclusion should as yet be drawn as to their distribution.

ACKNOWLEDGMENTS

This paper was written under much the same circumstances as was the "The Draco System" (Baade and Swope 1961). Dr. Baade selected the field and took all the plates and found the variables. Dr. Arp furnished

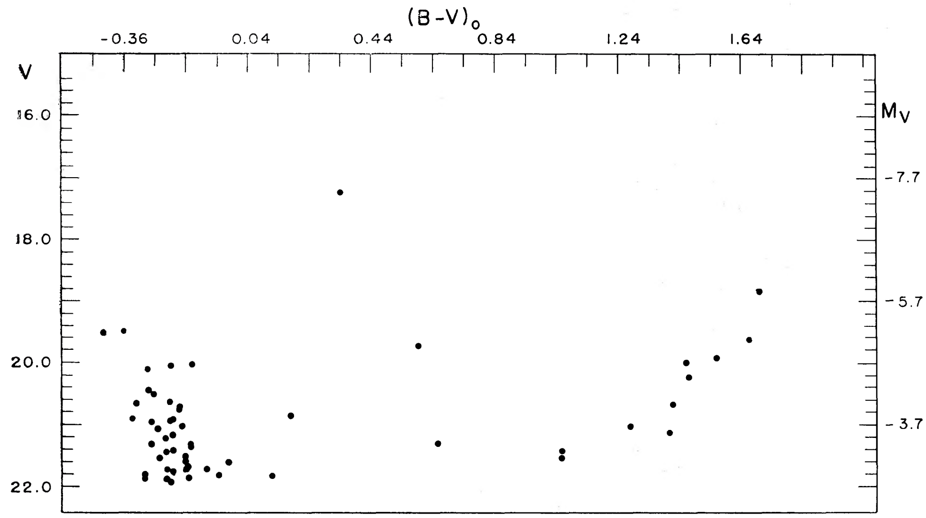


FIG. 19. Color–magnitude diagram of 3 small associations in spiral arms as shown in Plate IV.

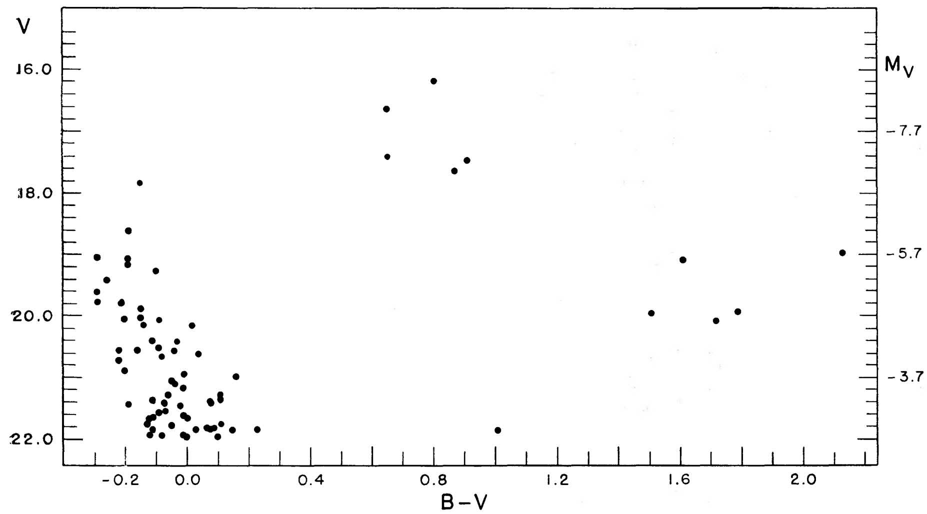


FIG. 20. Color–magnitude diagram of big, bright association in spiral arm as shown in Plate V.

the excellent photoelectric sequence, which represents many hours of valuable observing time at the telescope. In addition, much helpful advice was given to me by Drs. Kraft and Sandage and by others of the Observatory Staff.

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TABLE A. Photographic observations and phases of twenty Cepheids and seven "Population II" variables.

JD	V 2		V 3		V 5		V 8		V 9		V 10		V 11	
2,430,000+	B	Phase	B	Phase	B	Phase	B	Phase	B	Phase	B	Phase	B	Phase
4184.95	21.74	42.344	21.85	14.546	21.43	14.404	20.88	19.179	21.72	21.735	22.38	60.776	21.43	62.113
224.89	21.82	51.489	22.08	17.688	20.72	17.514	.59	23.321	.70	26.429	.63	73.901	.82	75.527
243.83	22.22	55.825	20.95	19.177	21.74	18.989	.54	25.285	.77	28.655	22.42	80.125	.57	81.888
244.84	21.51	56.056	21.06	.256	.90	19.068	20.95	.390	21.54	.774	21.88	.457	.65	82.227
245.84	.66	.285	.40	.335	.90	.146	21.25	.494	20.90	.891	22.41	.786	.94	.563
.90	.63	.299	.46	.340	.96	.151	.26	.500	.89	.897	.53	.805	.83	.583
246.81	.95	.507	.57	.411	21.76	.222	.35	.594	20.82	29.005	.60	81.105	.69	.889
277.75	21.99	63.591	21.23	21.844	20.78	21.631	.94	28.803	21.60	32.641	.45	91.271	.62	93.279
304.70	22.03	69.761	20.62	23.965	21.08	23.730	.09	31.597	21.39	35.807	22.30	100.127	.76	102.330
305.66	.08	.981	.39	24.040	.32	.805	21.71	.697	20.86	.920	21.81	.443	.87	.652
330.70*	22.20	80.714	20.40	26.010	21.25:	25.760	20.70	34.293	20.90	38.864	–	–	.40	111.062
334.64	21.98	81.616	21.40	.320	22.01	26.032	21.68	.702	21.46	39.327	22.34	109.966	.84	112.385
360.61	21.95	82.562	.33	28.362	21.82	28.084	.09	37.395	.51	42.379	21.85	118.500	.45	121.107
361.61	22.16	.791	21.67	.441	.81	.162	.33	.499	.77	.496	22.44	.829	.81	.443
362.67	21.70	83.033	22.06	.524	21.97	.245	21.75	.609	21.88	.621	22.40	119.177	21.74	.799
4596.91	21.99	136.663	20.85	46.948	20.82	46.487	21.70	61.900	21.08	70.149	22.55	196.150	21.80	200.466
597.88	22.08	.885	.62	47.024	.72	.563	20.76	62.000	.33	.263	21.86	.468	.70	.792
598.88	21.08	137.114	.69	.103	.83	.640	.68	.104	.54	.380	22.28	.797	.46	201.128
599.87	21.77	.340	20.95	.181	20.98	.717	.85	.206	.70	.497	22.38	197.122	.96	.460
600.88	21.99	.571	21.17	.260	21.43	.796	.90	.311	.88	.615	21.88	.454	.74	.799
601.96	22.29	.819	.30	.345	.48	.881	20.87	.423	.55	.742	22.38	.809	.38	202.162
602.88*	21.77	138.029	21.50	.417	.60	.952	21.15	.519	.05	.850	.40	198.112	.75	.471
625.77*	.51	143.270	20.95	49.217	.04:	48.735	.80	64.892	.80	73.540	.28	205.634	.55	210.158
.89	.55	.297	21.08	.227	.16	.744	21.50:	.905	.82	.554	.40	.673	.37	.198
626.77	.93	.499	.15	.296	.41	.813	20.98	.996	.69	.658	.60	.962	.88	.494
.87*	21.90	.522	.20	.304	.43	.820	.80	65.006	.70	.670	.63	.996	.90	.527
627.76	22.08	.726	.67	.374	.54	.890	.74	.099	21.55	.774	.22	206.288	–	–
628.91	21.89	.989	.72	.464	21.90	.978	.61	.218	20.86	.909	.55	.666	.67	211.212
629.76	.35	144.183	.93	.531	22.00	49.046	20.46	.306	.69	74.009	.48	.945	.80	.498
630.78	.79	.417	.83	.611	22.14	.125	21.09	.412	20.98	.130	.50	207.281	.64	.840
633.76	.21	145.099	.54	.846	21.50	.357	.54	.721	21.65	.480	.47	208.260	.72	212.840
634.85	.59	.349	21.34	.931	.33	.442	.68	.834	.84	.608	.28	.618	.53	213.208
660.75	21.57	151.279	20.44	51.969	.04	51.459	.16	68.520	21.77	77.651	.55	217.129	.60	221.906
663.80	22.00	.977	20.95	52.209	.00	.697	.57	.836	20.84	78.010	.48	218.138	.58	222.530
680.64	22.35	155.832	21.96	53.533	21.84	53.009	.09	70.582	20.81	79.989	.29	223.665	.94	228.585
681.69	21.32	156.073	.96	.615	22.00	.091	.02	.691	21.10	80.112	.68	224.010	.60	.938
682.66	21.56	.295	21.90	.692	21.84	.166	21.57	.792	21.16	.226	.03	.329	.65	229.264
714.65*	22.11	163.619	20.90	56.208	.00	55.657	20.80	74.109	20.75	83.986	–	–	.35	240.007
717.61	21.57	164.297	21.76	.441	.69	.888	21.09	.416	21.33	84.333	.65	235.814	.54	241.001
718.62	21.98	.528	21.84	.520	21.70	.966	21.22	.521	21.77	.452	22.53	236.146	21.70	.340
4923.95	22.06	211.538	21.84	72.670	21.68	71.957	21.62	95.814	21.78	108.582	22.20	303.619	21.69	310.298
924.95	22.25	.767	.86	.749	21.91	72.035	21.68	.917	.90	.700	.65	.948	.80	.634
925.95	21.93	.996	.42	.828	22.01	.113	20.95	96.021	21.21	.817	.49	304.276	.49	.970
926.95	.49	212.225	21.62	.906	21.86	.191	.76	.125	20.80	.935	.20	.605	.72	311.306
927.95*	21.83	.454	20.40	.984	.75	.269	–	–	20.90	109.053	–	–	.85	.642
928.95	22.10	.683	.63	73.063	.41	.347	.71	.332	21.11	.170	.27	305.262	.50	.978
929.95	22.36	.912	20.81	.141	21.29	.425	20.83	.436	.29	.287	.16	.591	.62	312.313
930.95	21.23	213.141	21.11	.220	20.70	.503	21.25	.540	.62	.405	.46	.919	.74	.650
931.94	21.75	.368	.25	.298	.84	.580	.40	.642	.60	.521	.50	306.245	.44	.981
932.96	22.11	.601	21.50	.378	20.93	.659	21.67	.748	.80	.640	.33	.580	.76	313.324
954.97	21.92	218.640	20.81	75.109	21.27	74.373	20.84	99.030	.25	112.227	.34	313.813	.78	320.716
979.83*	.78	224.332	.50	77.065	.45:	76.310	21.50	101.608	.05	115.150	–	–	.35	329.065
980.89*	21.91	.575	20.80	.148	.32	.392	.70	.718	.20	.274	–	–	.80	.421
981.88	22.07	.801	21.11	.226	21.10	.470	21.54	.821	.48	.390	.32	322.656	.78	.754
983.86	21.51	225.255	–	–	20.78	.624	20.74	102.026	.82	.622	.18	323.306	.76	330.419
984.92	21.96	.497	.72	.465	20.97	.706	.76	.136	.65	.748	.29	.657	.76	.775
985.86	22.15	.713	.88	.539	21.23	.780	.61	.234	.15	.858	.53	.964	.54	331.090
.98	22.15	.740	21.90	.549	.25	.790	20.64	.246	.11	.873	.53	324.003	.56	.131
5006.79	21.88	230.504	20.95	79.185	21.37	78.409	21.07	104.404	.31	118.318	.57	330.841	.61	338.119
007.81	22.15	.738	21.21	.265	20.80	.488	.15	.510	.55	.438	22.63	331.176	.86	.462
008.79	22.22	.962	.43	.343	.69	.565	.39	.612	.92	.553	21.94	.499	.74	.791
009.74	21.30	231.180	.48	.417	.90	.639	.60	.710	.70	.664	22.48	.811	.53	339.110
.82	.38	.198	.62	.424	20.88	.645	.62	.718	.82	.674	.48	.837	.48	.137
010.76	21.88	.413	.70	.498	21.00	.719	.65	.816	21.50	.784	22.53	332.146	–	–
011.79	22.03	.649	.86	.578	21.34	.799	.35	.922	20.94	.905	21.97	.485	.82	.798
035.74	21.23	237.133	.70	81.462	20.98	80.663	.04	107.406	21.82	121.720	21.95	340.354	.78	347.842
036.87	.75	.391	.82	.551	21.16	.751	.28	.523	21.05	.853	22.42	.726	.49	348.222
037.70	.98	.581	21.85	.617	.39	.816	.50	.609	20.70	.951	.54	.999	.90	.500
.84	22.00	.613	22.00	.627	.39	.827	.48	.624	.76	.967	.46	341.045	.88	.547
038.70	22.15	.810	22.02	.695	.56	.894	.56	.713	20.94	122.068	.20	.328	.68	.836
064.63	.10	243.747	21.96	83.734	.67	82.914	.20	110.402	21.02	125.115	.63	349.848	.87	357.544
065.63	22.06	.976	.44	.813	.71	.992	.23	.506	.19	.232	.68	350.176	.78	.880
066.63	21.39	244.205	21.48	.892	.92	83.070	.62	.610	.41	.350	.12	.505	.58	358.216
067.62	21.86	.432	20.45	.970	.93	.147	.76	.712	.67	.467	.40	.830	.85	.549
068.62	22.16	.661	.39	84.049	.84	.224	.67	.816	.86	.584	22.55:	351.159	.70	.884
069.62	.22	.889	.75	.127	.59	.302	.46	.919	.65	.702	21.94	.488	.59	359.220
.81	22.37	.933	20.84	.142	21.54	.317	.25	.939	21.58	.724	22.19	.550	.60	.284
097.63	21.62	251.302	21.28	86.330	20.97	85.483	.66	113.824	20.86	128.993	.34	360.692	.91	368.627
.76	.59	.332	.33	.340	.78	.493	.66	.838	20.81	129.009	.40	.735	.88	.670
098.64	21.93	.534	.59	.408	.64	.562	21.17	.929	21.05	.112	22.54	361.024	.51	.966
099.66	22.04	.767	21.80	.487	20.95	.641	20.85	114.035	.15	.232	21.82	.359	21.59	369.309
100.68	22.00	252.001	22.02	.569	21.09	.721	20.84	.140	21.56	.352	22.32	.695	22.04	.651

Table A (*continued*)

JD 2,430,000+	V 2 B	Phase	V 3 B	Phase	V 5 B	Phase	V 8 B	Phase	V 9 B	Phase	V 10 B	Phase	V 11 B	Phase
5342.82	21.90	307.439	22.16	105.614	20.66	104.579	20.61	139.250	21.42	157.808	22.48	440.264	21.53	450.971
370.89	22.29	313.865	21.46	107.822	21.20	106.765	.78	142.161	.00	161.107	.05	450.488	.71	460.398
371.74	21.46	314.060	-	-	.46	.831	.65	.249	-	-	.48	.767	.91	.684
.88	.23	.092	21.52	.900	.45	.842	.68	.264	.07	.223	.49	.813	.90	.730
372.76	.60	.293	-	-	.53	.910	.94	.355	.23	.327	.47	451.103	.46	461.026
373.94	.90	.564	-	-	21.74	107.002	20.98:	.478	-	-	.10	.490	.78	.423
394.69	21.78	319.314	22.15:	109.694	20.85	108.618	21.49	144.629	21.02	163.904	.00	458.309	.70	468.391
395.77	22.04	.562	21.67	.780	21.05	.703	.70	.741	20.78	164.031	.40	.664	.99	.754
.94	21.90	.600	.50	.792	.13	.716	.88	.759	21.03	.051	.38	.720	.80	.811
396.68	22.16	.770	.38	.851	.26	.773	.58:	.835	.11	.138	.70	.963	.40	469.060
.84	-	-	-	-	.25	.786	-	-	-	-	22.53	459.016	.41	.113
397.90	21.71	320.049	.00	.946	.43	.868	.10	.962	21.28	.282	21.70	.364	.85	.469
403.84*	21.86	321.409	21.50	110.413	21.40	109.331	21.39	145.578	20.70	.979	-	-	-	-
426.83*	22.03	326.673	20.90	112.222	22.00	111.122	20.98	147.962	21.65	167.681	-	-	-	-
450.69	21.35	332.135	20.66	114.098	21.93	113.980	21.03	150.437	21.70	170.485	22.45	476.711	21.57	487.198
5690.94	21.23	387.141	20.37	132.994	21.04	131.691	20.97	175.350	21.70	198.719	22.40:	555.660	21.70	567.883
692.88	22.07	.585	20.75	133.147	.26	.841	21.35	.550	20.85	.947	.34	556.297	.92	568.535
693.88	.16	.814	21.00	.226	21.47	.920	.50	.655	21.00	199.065	.20	.626	.80	.871
715.78	22.24	392.828	20.80	134.948	20.75	135.625	.40	177.926	.85	201.638	.65	563.822	.61	576.226
716.77	21.60	393.054	.55	135.026	21.04	.702	20.75	178.029	.52	.755	.55	564.148	.94	.558
717.79	.64	.288	20.63	.106	.22	.781	.80	.135	21.07	.875	.05	.483	.60	.901
718.77	.95:	.512	21.00	.183	.32	.858	20.65	.236	20.80	.990	.50	.805	.56	577.230
719.80	.95:	.749	.05	.264	.54	.938	21.05	.343	21.10	202.112	22.75	565.143	.91	.576
808.78	21.09	419.120	21.00	142.262	21.47	140.867	21.50	187.570	21.90:	212.567	21.80	594.383	21.85	607.459

JD 2,430,000+	V 13 B	Phase	V 15* B	Phase	V 16* B	Phase	V 17 B	Phase	V 21 B	Phase	V 26* B	Phase	V 27 B	Phase
4184.95	22.68	48.633	19.90	8.698	22.40	73.578	22.06	27.474	22.20	55.246	21.76	46.881	21.82	71.332
224.89	.46	59.135	21.20	10.576	.73	89.468	.58	33.407	.02	67.177	21.74	56.005	22.68	86.735
243.83	.39	64.115	.35	11.467	.73	97.003	.12	36.221	22.65	72.834	22.06	61.806	.60	94.040
244.84	.98	.381	.40	.514	.78	.405	.14	.371	21.99	73.136	.16	62.062	.12	.430
245.84	.85	.644	.26	.561	.53	.802	.14	.519	22.38	.434	.12	.315	.54	.815
.90	.84	.660	.23	.563	.53	.826	22.22	.528	.55	.452	.28	.330	.48	.838
246.81	.04	.899	21.46	.608	.73	98.188	21.35	.664	22.58	.724	.32	.561	.43	95.189
277.75	.16	73.034	20.93	13.062	-	-	22.26	41.260	21.88	82.967	-	-	.63	107.123
304.70	.36	80.121	21.15	14.330	-	-	.28	45.263	21.60	91.017	.28	77.235	.10	117.517
305.66	.80	.373	.50	.376	.20	121.601	.40	.406	22.44	.304	22.32	.479	.85	.888
330.70*	.20	86.957	21.50	15.553	.24	131.562	22.10	49.125	22.73	98.783	21.76	83.826	.31	127.544
334.64	.21	87.993	19.85	.738	-	-	21.30	.711	21.69	99.960	21.92	84.825	.57	129.064
360.61	.70	94.822	20.65	16.959	.73	143.461	.76	53.569	22.44	107.718	22.32	91.407	.58	139.080
361.61	.29	95.085	.75	17.006	22.58	.859	.30	.717	21.71	108.017	.32	.661	.21	.466
362.67	22.77	.364	20.70	.053	-	-	21.52	.878	22.58	.333	22.04	.930	22.55	.874
4596.91	22.07	156.957	20.80	28.073	22.63	237.469	21.23	88.671	22.30	178.303	-	-	22.26	230.216
597.88	.68	157.212	20.90	.118	.68	.855	.55	.815	.50	.593	22.20	151.551	.38	.590
598.88	.98	.474	21.11	.165	.68	238.252	.88	.964	22.24	.891	.00	.804	22.60	.976
599.37	.59	.735	.11	.213	.16	.646	21.99	89.111	21.98:	179.191	.14	152.055	21.92	231.358
600.38	.25	158.000	.30	.260	.58	239.048	22.18	.261	22.50	.489	.24	.311	22.51	.747
601.96	.80	.284	.40	.309	.44	.478	.12	.421	22.58	.811	22.32	.585	.38	232.164
602.88*	.73	.527	.26	.354	.63	.844	22.00	.558	21.88	180.086	21.76	.818	22.14:	.519
625.77*	.83	164.546	.40	29.430	-	-	21.70	92.958	.95	186.924	22.36	158.620	21.85	241.347
.89	.82	.578	.50	.436	.73	248.998	.85	.976	21.62	.960	22.40	.650	22.04	.393
626.77	.74	.809	.46	.477	(22.7	249.348	21.94	93.107	22.20	187.223	21.58	.873	.48	.733
.87*	.60	.835	.50	.482	(22.7	.388	22.00	.121	.28	.252	21.60	.898	.55	.772
627.76	.49	165.069	.30	.524	-	-	.38	.254	.36	.518	-	-	.45	242.114
628.91	.70	.372	.35	.578	22.63	250.199	22.22	.424	22.50	.862	22.38	159.416	.28	.557
629.76	.95	.595	21.46	.617	.36	.537	21.82	.551	21.94	188.116	22.42	.631	22.70	.885
630.78	.24	.863	20.63	.665	-	-	21.23	.702	22.53	.420	21.88	.890	21.88	243.279
633.76	.68	166.647	.05	.805	(22.8	252.129	22.06	94.145	.20	189.310	-	-	22.24	244.428
634.85	.38	.933	.14	.856	22.36	.562	22.42	.307	.60	.636	21.70	160.922	.58	.848
660.75	.73	173.744	20.71	31.075	.53	262.866	21.98	98.154	.40	197.373	22.20	167.487	.60	254.838
663.80	.75	174.546	21.30	.218	(22.7	264.079	.62	.607	.26	198.284	.20	168.260	.80	255.014
680.64	.15	178.974	20.84	32.010	22.63	270.779	21.98	101.109	.40	203.314	.36	172.529	.22	262.509
681.69	.66	179.250	20.75	.060	.73	271.197	22.10	.265	.60	.628	22.02	.795	22.60	.914
682.66	22.75	.505	21.19	.105	.28	.582	22.26	.409	.00	.918	21.99	173.041	21.84	263.288
714.65*	21.95	187.917	21.30	33.610	-	-	-	-	-	-	22.10	181.149	22.50	275.626
717.61	22.89	188.695	19.71	.749	.44	285.487	21.68	106.601	.48	214.357	21.72	.900	.78	276.768
718.62	21.94	.961	19.85	.796	22.63	.858	21.26	.751	22.68	.659	22.16	182.155	22.63	277.157
4923.95	22.20	242.953	21.40	43.453	22.20	367.575	22.24	137.253	21.64	275.993	22.05	234.203	22.04	356.349
924.95	.75	243.216	.23	.500	-	-	22.50	.401	22.60:	276.292	.36	.456	.69	.735
925.95	.93	.479	.50	.547	.73	368.371	21.86	.550	.60	.590	22.34	.710	.42	357.120
926.95	.83	.742	.30	.594	.63	.768	.13	.698	.36	.889	21.98	.963	.30	.506
927.95*	.10	244.004	21.20	.641	-	-	.35	.847	.08:	277.188	22.24	235.217	22.70	.892
928.95	.76	.267	20.45	.688	.28	369.564	21.94	.995	.53	.487	.34	.470	21.92	358.277
929 95	.88	.530	19.77	.735	.68	.962	22.06	138.144	22.55	.785	(22.4	.724	22.40	.663
930 95	.87	.793	.77	.782	(22.7	370.360	.34	.293	21.78	278.084	21.92	.977	22.58	359.048
931 94	.28	245.053	.85	.829	22.63	.754	22.48	.440	22.20	.380	22.24	236.228	21.96	.430
932 96	.58	.322	19.94	.877	-	-	21.78	.591	.73	.684	.36	.486	22.68	.823
954.97	.22	251.109	20.05	44.911	.48	379.916	.52	141.861	.16	285.259	.34	241.066	21.65	368.313
979.83*	.73	257.646	20.90	46.081	22.58	389.806	.80	145.554	22.73	292.685	22.32	248.367	22.60:	377.901
980.89*	22.16	.925	21.10	.131	-	-	21.30	.711	21.55	293.002	-	-	21.75:	378.310

TABLE A (*continued*)

JD 2,430,000+	V 13 B	V 13 Phase	V 15* B	V 15* Phase	V 16* B	V 16* Phase	V 17 B	V 17 Phase	V 21 B	V 21 Phase	V 26* B	V 26* Phase	V 27 B	V 27 Phase
4981.88	22.49	258.185	21.30	46.178	22.28	390.621	21.58	145.858	22.63	293.297	21.84	248.887	22.40	378.691
983.86	.90	.706	.39	.271	.83	391.409	22.10	146.152	.28	.887	22.46	249.389	.20	379.455
984.92	.22	.985	.26	.319	.53	.831	.20	.310	.20	294.205	22.28	.657	.63	.864
985.86	.60	259.232	.40	.365	(22.7	392.205	.34	.449	.55	.486	21.80	.896	22.14	380.226
.98	.54	.263	.40	.371	22.73	.253	22.33	.466	.50	.521	.84	.926	21.98	.272
5006.79	.78	264.735	.28	47.349	.16	400.531	21.84	149.559	22.80	300.738	21.98	255.201	21.88	388.299
007.81	.30	265.003	.19	.396	.53	.937	.23	.710	21.75	301.042	22.30	.459	22.60	.693
008.79	.58	.261	.39	.443	.68	401.327	.64	.856	22.42	.335	22.34	.707	.52	389.071
009.74	.73	.511	.45	.488	.58	.705	.88	.997	-	-	21.84	.948	.02	.436
.82	.95	.531	.39	.492	.44	.736	21.94	150.009	22.81	.643	21.86	.968	.30	.468
010.76	.73	.778	.35	.536	.73	402.111	22.02	.148	21.92	.924	22.30	256.207	.80	.830
011.79	.24	266.049	21.25	.584	.24	.520	22.27	.301	22.25	302.232	.30	.468	.16	390.227
035.74	.85	272.348	19.89	48.711	.68	412.048	21.55	153.859	.32	309.386	22.30	262.539	.16	399.464
036.87	.89	.645	.83	.764	.53	.498	22.02	154.027	22.65	.723	21.80	.826	.61	.900
037.70	.30	.864	.91	.803	.58	.828	.13	.150	21.64	.971	22.00	263.036	22.20	400.220
.84	.10	.900	19.89	.809	.68	.884	.10	.171	21.58	310.013	.02	.072	21.78	.274
038.70	.42	273.126	20.08	.850	(22.7	413.226	.26	.299	22.28	.270	22.24	.290	22.48	.606
064.63	.06	279.944	.57	50.069	22.28	423.542	.06	158.151	21.78	318.016	21.78	269.862	.48	410.606
065.63	.63	280.207	20.96	.116	.48	.939	.25	.299	22.34	.314	22.12	270.116	22.73	.992
066.63	.85	.470	21.19	.164	.78	424.337	22.45	.448	.63	.613	.36	.369	21.96	411.377
067.62	.93	.730	.23	.210	.58	.731	21.58	.595	.02	.909	22.32	.620	22.42	.759
068.62	.12	.994	.27	.257	.78	425.129	.30	.743	.16	319.207	21.91	.874	.68	412.145
069.62	.65	281.257	.26	.304	.36	.527	.57	.893	.48	.506	22.24	271.127	.43	.531
.81	.80	.307	.30	.314	.16	.603	21.67	.921	.42	.563	.08	.175	.34	.604
097.63	.83	288.622	.42	51.621	.28	436.670	22.13	162.053	.35	327.873	.32	278.227	.00	423.334
.76	.83	.656	21.30	.627	.53	.722	.12	.072	.03	.912	.30	.260	.00	.384
098.64	.12	.887	20.64	.669	.83	437.072	.17	.203	.02	328.175	.28	.463	.59	.723
099.66	.40	289.156	19.80	.716	.63	.478	.29	.354	.44	.479	.22	.742	.57	424.117
100.68	22.68	.424	19.83	.764	22.63	.883	22.16	.506	22.50	.784	22.14	279.000	22.41	.510
5342.82	22.34	353.094	21.19	63.153			22.28	199.476	21.88	401.114			22.56	517.899
370.89	.77	360.475	.42	64.472			21.35	203.646	22.44	409.479			.50	528.725
371.74	.85	.699	-	-			-	-	.72	.752			.73	529.062
.88	.84	.736	.30	.519			21.40	.793	22.70	.794			.60	.107
372.76	.20	.967	-	-			-	-	21.82	410.057			.04	.446
373.94	.80	361.278	.19	.616			-	-	22.36	.410			.50	.901
394.69	.56	366.734	.50	65.593			22.16	207.181	22.45	416.608			.88	537.904
395.77	.26	367.018	.40	.643			.22	.341	21.85	.930			22.00	538.321
.94	.26	.054	.09	.651			.20:	.360	21.56	.970			21.97	.373
396.68	.73	.257	20.45	.686			22.50	.477	22.23	417.202			22.65	.672
.84	22.78	.299	-	-			-	-	-	-			.53	.733
397.90	23.00	.578	19.70	.743			21.20	.657	.70:	.567			.75	539.142
403.84*	22.40	369.140	20.78	66.023			.90:	208.540	-	-			.00:	541.433
426.83*	.50	375.185	20.94	67.103			21.80:	211.956	-	-			-	-
450.69	22.80	381.459	21.22	68.226			22.13	215.500	22.47	433.336			22.35	559.502
5690.94	22.80	444.633	21.45	79.525			22.00	251.189	21.90	505.101			22.60	652.162
692.88	.40	445.143	.47	.616			22.17	.477	22.65	.680			22.55	.910
693.88	.75	.406	21.00	.663			21.50	.624	21.65	.979			21.92	653.296
715.78	.61	451.164	20.15	80.693			.50	254.879	22.80	512.521			22.55	661.742
716.77	.76	.425	19.75	.740			21.90	255.026	.60:	.816			.57	662.124
717.79	.71	.693	.82	.788			22.05	.178	.08	513.121			.45	.517
718.77	.03	.950	19.87	.834			.05:	.323	.55	.414			22.90	.895
719.80	.55	452.221	20.15	.882			22.20	.476	.70	.721			21.83	663.292
808.78	22.95	475.619	20.62	85.068			21.17	268.694	22.43	540.301			22.40	697.610

JD	V 30 B	V 30 Phase	V 31 B	V 31 Phase	V 36 B	V 36 Phase	V 42* B	V 42* Phase	V 46 B	V 46 Phase	V 48 B	V 48 Phase
4184.95	21.45	14.361	20.40	13.868	22.36	51.470	22.08	59.694	23.01	49.838	23.10	54.346
224.89	20.73	17.461	.46	16.863	.58	62.585	21.72	72.585	22.78	60.601	22.65	66.082
243.83	21.79	18.932	.64	18.283	.93	67.855	.88	78.698	22.95	65.705	.90	71.647
244.84	22.00	19.010	.57	.359	.58	68.136	-	-	23.29	.978	.58	.944
245.84	.12	.085	.44	.434	.30	.415	-	-	.29	66.247	.68	72.237
.90	22.08	.093	.48	.438	.42	.431	-	-	23.44	.263	.78	.255
246.81	21.90	.164	.34	.506	.63	.684	.82	79.660	22.63	.509	.83	.522
277.75	20.97	21.567	.33	20.827	.16	77.295	-	-	23.07	74.845	-	-
304.70	20.97	23.660	.41	22.848	.93	84.795	-	-	-	-	-	-
305.66	21.27	.734	.53	.920	.93	85.062	21.96	98.655	.38	82.366	.38	89.815
330.70*	21.10	25.679	.30	24.798	-	-	22.04:	107.737	-	-	-	-
334.64	22.02	.985	.81	25.093	.53	93.127	22.08	108.008	-	-	-	-
360.61	21.84	28.001	.75	27.040	.16	100.354	21.96	116.389	23.26	97.174	.68	105.962
361.61	.94	.079	.78	.115	22.68	.632	-	-	22.58	.444	.83	106.256
362.67	21.70	.161	20.69	.194	-	-	(22.1	117.055	23.10	.729	22.93	.567
4596.91	21.40	46.350	20.19	44.759	22.64	166.114	21.[illegible]6	192.659	23.08	160.849	22.92	175.396
597.88	21.37	.425	.34	.832	.26	.384	22.12	.972	.32	161.110	.78	.681
598.88	20.78	.503	.41	.907	.60	.662	-	-	.20	.380	.63	.975
599.87	20.81	.580	.52	.981	.93	.938	21.69	193.614	.08	.648	-	-
600.88	21.10	.658	.71	45.057	.16	167.219	22.04	.940	.32	.919	.88	176.562
601.96	.25	.742	.83	.138	.48	.519	22.08	194.289	23.26	162.210	.53	.880
602.88*	21.40	.814	.84	.207	.70	.775	21.80	.585	22.73	.458	-	-
625.77*	20.90	48.591	.48	46.923	.40	174.146	22.08	201.973	.83	168.626	-	-
.89	20.98	.600	20.51	.932	22.36	.179	22.12	202.012	22.93	.658	22.58	183.912

TABLE A (*continued*)

JD 2,430,000+	V 30 B	V 30 Phase	V 31 B	V 31 Phase	V 36 B	V 36 Phase	V 42* B	V 42* Phase	V 46 B	V 46 Phase	V 48 B	V 48 Phase
4626.77	21.03	48.668	20.64	46.998	22.24	174.424	22.04	202.295	23.41	168.905	22.68	184.170
.87*	.10	.676	.65	47.006	.40	.452	22.12	.328	-	-	-	-
627.76	.35	.745	.66	.073	.78	699	21.96	.616	23.44	169.162	.73	.461
628.91	.65	.834	.84	.159	.88	175.019	22.08	.987	22.60	.472	.24	.799
629.76	.58	.900	.80	.222	.00	.256	-	-	22.88	.701	.83	185.049
630.78	.82	.979	.75	.299	.38	.540	21.62	203.590	23.19	.976	.88	.348
633.76	.76	49.211	.30	.522	.22	176.369	21.50	204.552	.33	170.779	22.93	186.224
634.85	.64	.283	.22	.604	.80	.672	22.04	.904	.38	171.073	23.03	.544
660.75	21.41	51.307	.28	49.546	.70	183.880	.12	213.264	.50	178.052	22.90	194.155
663.80	20.88	.544	.22	.775	.75	184.728	22.28	214.248	.26	.874	-	-
680.64	21.62	52.852	.69	51.038	.38	189.415	21.88	219.683	23.10	183.413	22.95	200.000
681.69	.84	.933	.84	.117	.53	.707	22.28	220.022	22.93	.696	-	-
682.66	21.88	53.009	.82	.189	.75:	.977	22.22	.335	23.41	.957	23.14	.593
714.65*	20.75	55.492	.20	53.588	.90	198.880	21.72	230.660	-	-	-	-
717.61	21.35	.722	.32	.810	.70	199.703	.72	231.616	23.11	193.374	22.48	210.863
718.62	21.46	.800	20.46	.886	22.93	.984	21.96	.942	22.94	.646	22.95	211.160
4923.95	-	-	20.72	69.282	22.42	257.126	22.04	298.214	23.22	248.977	22.98	271.493
924.95	21.45	71.823	.60	.357	.18	.404	21.54	.537	23.35	249.247	22.44	.787
925.95	.70	.900	.55	.432	.63	.683	-	-	22.75	.516	23.00	272.081
926.95	.88	.978	.32	.507	.95	.861	22.04	299.182	23.30:	.787	22.83	.374
927.95*	.90	72.055	.13	.582	.05	258.239	21.69	.505	-	-	-	-
928.95	.90	.133	.13	.657	.40	.517	22.12	.829	-	-	.78	.962
929.95	.84	.211	.14	.732	.80	.796	-	-	22.70	250.593	.88	273.256
930.95	.46	.289	.32	.807	22.83	259.074	21.92	300.473	23.38	.863	.95	.550
931.94	.60	.365	.47	.881	21.98	.349	22.00	.793	-	-	.29	.841
932.96	21.10	.445	.55	.957	22.48	.633	22.28	301.122	22.90	251.405	22.80	274.141
954.97	22.06	74.153	.06	71.608	.88	265.758	-	-	23.14	257.338	23.08	280.608
979.83*	21.90	76.084	-	-	.55	272.677	-	-	-	-	-	-
980.89*	.90	.166	.30	73.552	.90	.972	21.50	316.592	-	-	-	-
981.88	.86	.243	.19	.626	.24	273.247	.85	.911	22.90	264.587	23.14	288.516
983.86	21.39	.397	.17	.774	.80	.798	.76	317.551	23.26	265.121	22.65	289.098
984.92	20.82	.479	.43	.854	.88	214.092	21.92	.893	22.85	.406	.83	.409
985.86	.88	.552	.48	.924	.18	.354	22.28	318.196	.75	.660	.88	.686
.98	20.86	.562	.52	.933	.30	.387	.28	.235	22.82	.692	.65	.721
5006.79	21.82	78.177	.44	75.494	.40	280.179	.16	324.952	23.14	271.300	.38	295.835
007.81	.70	.256	.25	.570	.48	.463	22.28	325.281	22.67	.575	.88	296.135
008.79	.54	.332	.17	.644	.68	.735	21.72	.597	23.20	.839	.93	.423
009.74	.30	.406	.10	.715	.75	281.000	22.28	.904	.30:	272.095	.74	.702
.82	21.31	.412	.18	.721	22.83	.022	.16	.929	.22	.117	.55	.726
010.76	20.78	.485	.25	.791	21.98	.284	22.28	326.233	23.29	.370	.73	297.002
011.79	20.90	.565	.45	.869	22.50	.570	21.72	.565	22.90	.648	.83	.305
035.74	21.20	80.425	.16	77.665	.11	288.236	22.04	334.295	23.18	279.101	.84	304.342
036.87	20.80	.513	.16	.749	.62	.551	21.88	.660	22.85	.405	.82	.675
037.70	.85	.578	.35	.812	.62	.782	22.16	.928	.91	.629	.54	.918
.84	20.94	.588	.32	.822	.78	.821	22.28	.973	22.88	.667	.75	.960
038.70	21.19	.655	.46	.887	.70	289.060	-	-	23.32	.899	.70	305.212
064.63	.06	82.669	.35	79.831	.10	296.276	21.80	343.620	23.38	286.886	.40	312.831
065.63	.45	.747	.54	.906	.50	.555	22.04	.943	-	-	.79	313.125
066.63	.64	.824	.66	.981	.77	.833	22.28	344.265	22.70	287.425	.82	.419
067.62	.74	.902	.80	80.055	-	-	21.69	.585	23.22	.692	.70	.710
068.62	21.82	.979	.84	.130	.19	297.386	22.08	.908	.41	.961	.71	314.004
069.62	22.00	83.057	.88	.205	.63	.665	.32	345.231	.40	288.231	.71	.297
.81	22.00	.071	.82	.219	.88	.717	-	-	.20	.282	22.98	.353
097.63	21.65	85.231	.78	82.306	.31	305.459	-	-	.04	295.778	23.14	322.528
.76	.74	.241	.69	.316	.42	.495	22.16	354.313	.41	.813	-	-
098.64	.55	.309	.57	.382	.72	.740	21.62	.597	.32	296.050	22.27	.824
099.66	21.47	.389	.46	.459	.80	306.024	22.04	.926	23.23	.225	22.84	323.124
100.68	20.86	.468	20.37	.535	22.16	.308	22.08	355.255	22.78	.600	-	-
5342.82	21.58	104.270	20.06	100.691	22.42	373.693			22.98	361.850	-	-
370.89	21.00	106.449	.27	102.796	.42	381.505			.96	369.414	22.36	402.822
371.74	20.88	.515	.43	.860	.70	.748			22.95	.648	-	-
.88	20.83	.526	.37	.870	.89	.780			23.00	.681	.75	403.113
372.76	21.00	.594	.46	.936	-	-			.23	.917	-	-
373.94	-	-	.63	103.025	-	-			.32	370.236	-	-
394.69	.40	108.298	.20	104.581	.75:	388.128			.10	375.827	.35:	409.816
395.77	21.42	.381	.11	.662	.24	.428			.20	376.118	22.75	410.132
.94	-	-	.03	.675	.32	.467			.20	.164	23.03	.183
396.68	20.90	.452	.15	.730	.72	.682			.00:	.363	22.73	.400
.84	.72	.465	.18	.742	-	-			23.10:	.406	.73	.447
397.90	20.80	.547	.36	.821	.70:	389.021			22.95	.692	.35	.758
403.84*	22.00	109.008	.70	105.267	.60	390.675			-	-	-	-
426.83*	21.40	110.793	.70	106.991	-	-			-	-	-	-
450.69	21.09	112.646	20.24	108.780	22.60:	403.712			23.10:	390.917	22.90	426.271
5690.94	21.40	131.301	20.18	126.795	22.30	470.571			22.75	455.658	22.45	496.866
692.88	20.90	.452	.55	.941	.70	471.111			-	-	.85:	497.436
693.88	20.82	.530	.73	127.016	.10	.390			.55	456.451	.60	.729
715.78	21.60	133.230	.13	128.658	.30	477.484			-	-	.80	504.165
716.77	.37	.307	.20	.732	.65	.760			22.75:	462.618	.80	.456
717.79	21.40	.386	.30	.808	.75	478.044			23.00	.893	.50	.755
718.77	20.95	.452	.39	.882	.00	.361			23.20	463.157	.70	505.044
719.80	.72	.542	.55	.959	.50	.601			22.70	.435	.80	.346
808.78	20.95	140.451	20.20:	135.631	22.20	503.365			22.90	487.412	22.90:	531.495

TABLE A (*continued*)

JD	V 22		V 24		V 25*		V 34*		V 53*		V 55		V 57	
2,430,000+	B	Phase	B	Phase	B	Phase	B	Phase	B	Phase	B	Phase	B	Phase
4184.95	22.40	4.958	21.83	3.999	22.12	4.690	21.64	2.983	22.48	9.307	23.14	9.604	22.18	3.459
224.84	21.80	6.029	.85	4.862	21.88	5.703	.45	3.627	.15	11.316	22.98	11.678	.10	4.205
243.83	22.20	.537	.27	5.271	22.04	6.183	.33	.933	.73	12.269	(23.0	12.662	.13	.560
244.84	.14	.564	.33	.292	21.80	.209	.54	.951	.48	.320	22.98	.714	22.30	.578
245.84	.30	.591	.33	.314	22.16	.235	.33	.966	.18	.370	(23.0	.766	21.98	.597
.90	.28	.593	.39	.315	.20	.237	-	-	-	-	23.26	.769	21.90	.598
246.81	.26	.617	21.29	.336	.16	.259	.31	.981	.53	.419	.14	.817	22.02	.615
277.75	22.20	7.446	22.10	6.006	(22.3	7.044	.67	4.480	.73	13.976	-	-	.06	5.194
304.70	21.50	8.170	21.30	.588	21.60	.727	.20:	.915	.27	15.332	(22.7	15.823	.08	.698
305.66	21.84	.195	.37	.609	21.76	.752	.33	.931	.63	.381	23.26	.873	22.00	.716
330.70*	22.50	.866	.40	7.150	22.10	8.386	.10:	5.334	.59	16.641	22.40	17.173	21.90	6.184
334.64	.44	.972	.48	.234	21.90	.486	.19	.398	.73	.839	.60	.378	22.18	.258
360.61	.02	9.668	.48	.796	22.73	9.145	.45	.817	.83	18.146	(22.7	18.726	.03	.743
361.61	.32	.695	.58	.818	.48	.170	.70	.833	.73	.196	(22.7	.728	.20	.762
362.67	22.40	.723	21.86	.841	22.48	.197	21.31	.850	22.36	.249	23.0:	.833	22.26	.781
4596.91	21.60	16.003	21.65	12.905	22.28	15.138	21.64	9.628	22.98	30.036	22.52	30.997	21.80	11.162
597.88	.60	.029	.69	.926	.48	.162	.64	.644	.98	.085	.50	31.048	.85	.180
598.88	.60	.056	.74	.948	.32	.188	.70	.660	.68	.136	.40	.100	.92	.199
599.87	.76	.083	.82	.970	.73	.213	.70	.676	.83	.185	.40	.151	21.86	.217
600.88	.62	.110	.76	.991	.73	.238	.67	.692	.73	.236	.24	.203	22.03	.235
601.96	.67	.139	.76	13.013	.98	.266	.62	.709	.53	.290	.22	.260	21.90	.257
602.88*	21.65	.163	.60	.034	22.98	.289	21.76	.724	.28	.337	.51	.307	22.10	.274
625.77*	22.40	.777	.00	.529	21.65	.870	20.90	10.094	.63	31.489	.95	32.496	.10	.702
.89	.58	.780	.10	.530	.65	.873	.97	.096	.49	.495	22.93	.502	.24	.704
626.77	.60	.804	21.10	.551	.70	.895	20.97	.110	.44	.539	23.08	.548	.02	.720
.87*	.65	.806	20.95	.553	.80	.897	21.05	.111	.36	.545	.00	.553	22.10	.722
627.76	.75	.830	21.29	.573	.80	.920	20.91	.128	.36	.586	(22.9	.600	21.86	.739
628.91	.50	.861	.21	.595	.72	.949	20.97	.144	.60	.647	22.93	.659	22.02	.761
629.76	.65	.884	.13	.616	21.88	.971	21.02	.158	-	-	(23.0	.703	21.84	.776
630.78	.90	.911	.27	.638	22.08	.997	.17	.175	(22.5	.741	(23.0	.756	.86	.795
633.76	22.10	.990	.17	.702	.28	16.072	21.06	.223	22.73	.891	22.88	.911	.94	.851
634.85	21.92	17.020	.33	.724	22.12	.100	20.94	.239	.83	.946	.70	.968	.72	.871
660.75	22.46	.715	.15	14.286	21.88	.757	21.64	.658	.53	33.249	.26	34.313	21.94	12.356
663.80	22.32	.797	.02	.351	21.76	.834	.67	.708	.36	.403	.98	.471	22.14	.413
680.64	21.72	18.248	.50	.715	22.63	17.261	.41	.979	(22.7	34.250	.32	35.346	.22	.728
681.69	.65	.276	.50	.738	.98	.288	.29	.995	22.36	.303	.38	.400	.18	.748
682.66	.74	.302	.76	.759	22.98	.312	.17	11.011	.44	.351	.98	.450	.17	.766
714.65*	.45	19.159	.90:	15.470	21.80	18.124	-	-	(22.4	35.961	22.30:	37.111	.15	13.364
717.61	.71	.239	.67	.514	.80	.199	.33	.575	(22.7	36.110	.58	.265	.06	.419
718.62	21.78	.266	21.76	.536	21.88	.224	21.58	.591	(22.7	.161	22.34	.318	22.14	.438
4923.95	22.60	24.771	20.95	19.975	22.98	23.431	21.46	14.903	22.08	46.493	22.68	47.981	22.34	17.278
924.95	.50	.798	21.04	.996	.83	.457	.33	.909	(22.3	.543	.24	48.033	.28	.296
925.95	.53	.825	21.04	20.018	22.63	.482	.65	.936	22.63	.593	.42	.084	.20	.315
926.95	.78	.851	20.98	.040	23.03	.507	.56	.952	.53	.644	.53	.136	.09	.334
927.95*	.70	.878	21.05	.062	22.90	.533	-	-	(22.3	.694	.60	.188	.30	.353
928.95	.95	.905	.10	.083	.93	.558	.37	.983	22.73	.745	.38	.240	.45	.371
929.95	.55	.932	.19	.104	.40	.584	.39	15.000	.73	.795	.40	.292	.24	.390
930.95	.78	.959	.19	.126	.00	.609	.31	.016	(22.7	.845	.70	.344	.24	.409
931.94	.80	.985	.19	.148	22.00	.634	.10	.032	-	-	.73	.396	.36	.428
932.96	22.40	25.013	.36	.170	21.65	.660	.11	.047	(22.5	.947	.78	.449	22.30	.446
954.97	21.74	.603	.23	.645	22.70	24.218	.30	.404	23.00	48.054	23.05	49.591	21.90	.857
979.83	.70	26.269	.35	21.184	.10	.848	-	-	22.28	49.305	-	-	22.10:	18.323
980.89	.80:	.298	.50	.207	.10	.875	-	-	.36	.358	22.70:	50.938	.10:	.343
981.88	21.89	.324	.86	.228	22.00	.900	.48	.838	.44	.398	.70	.989	.18	.361
983.86	22.08	.377	.65	.272	21.92	.951	.58	.870	.58	.497	.44	51.092	.26	.398
984.92	22.10	.405	.69	.293	22.00	.978	.69	.886	.63	.561	.32	.147	.14	.417
985.86	21.98	.431	.84	.315	.08	25.001	.45	.902	.73	.608	.40	.195	.10	.436
.98	22.02	.433	21.88	.316	21.88	.004	-	-	.63	.614	-	-	22.18	.437
5006.79	.30:	.992	20.99	.767	22.28	.532	.04	16.239	.63	50.662	.48	52.282	21.93	.827
007.81	.08	27.019	.95	.789	21.88	.558	.02	.255	.68	.713	.40	.335	22.03	.846
008.79	22.04	.046	20.95	.810	22.12	.583	.06	.271	.78	.762	.63	.386	21.78	.864
009.74	21.75	.071	21.10	.831	22.16	.607	.15	.286	.73	.810	-	-	.87	.882
.82	.74	.073	20.98	.832	-	-	21.09	.287	.63	.814	.71	.440	.72	.883
010.76	.67	.098	20.98	.853	21.88	.633	20.97	.304	(22.5	.861	.90	.489	.90	.901
011.79	21.45	.126	21.00	.875	21.80	.659	21.21	.320	22.83	.913	22.98	.542	21.89	.921
035.74	22.30	.768	.74	22.392	22.48	26.266	.69	.706	.83	52.118	(23.0	53.786	22.18	19.367
036.87	.26	.798	.67	.414	.46	.295	.70	.722	.73	.175	23.05	.845	.23	.388
037.70	.20	.821	.74	.435	.53	.316	.72	.737	(22.7	.217	-	-	.22	.405
.84	.24	.824	.85	.436	.48	.320	.78	.738	-	-	(23.0	.895	.20	.408
038.70	.30	.848	.86	.457	.44	.341	.64	.753	(22.5	.267	(23.0	.940	22.24	.423
064.63	.06	28.543	.29	23.017	.12	.999	.10	17.172	22.60	53.572	22.53	55.286	21.94	.908
065.63	.12	.570	.30	.038	.12	27.024	21.02	.189	.50	.622	.70	.338	22.08	.927
066.63	.14	.596	.30	.060	.28	.050	20.92	.205	.73	.673	.48	.390	22.08	.945
067.62	.30	.623	.33	.081	.53	.075	21.08	.220	.58	.722	.73	.442	21.98	.964
068.62	.28	.650	.22	.103	.12	.100	20.88	.237	.73	.773	.73	.493	22.08	.983
069.62	.38	.677	.36	.125	.28	.126	.94	.253	.73	.823	(23.0	.545	21.90	20.001
.81	22.44	.682	.31	.126	22.20	.130	20.91	.256	.63	.832	22.93	.555	21.90	.005
097.63	21.90	29.427	.28	.730	21.87	.836	21.73	.705	.44	55.233	.82	57.000	22.08	.525
.76	22.00	.431	.21	.731	.76	.839	-	-	.58	.239	.68	.007	.18	.528
098.64	21.98	.454	.23	.752	.69	.862	.80	.721	.28	.284	.46	.052	.18	.544
099.66	21.95	.482	.15	.774	.69	.887	.72	.739	.28	.335	.32	.105	.18	.562
100.68	22.00	.509	21.08	.797	21.80	.913	21.82	.754	22.16	.386	22.55	.158	22.10	.583

TABLE A (*continued*)

JD 2,430,000+	V 22 B	V 22 Phase	V 24 B	V 24 Phase	V 25* B	V 25* Phase	V 34* B	V 34* Phase	V 53* B	V 53* Phase	V 55 B	V 55 Phase	V 57 B	V 57 Phase
5342.82	22.40:	36.001	21.19	29.031	21.88	34.054	21.80	21.660	(22.3	67.571	-	-	21.93	25.112
370.89	21.84	.754	.70	.637	.80	.766	20.97	22.112	(22.7	68.983	22.40	71.190	22.15	.636
371.74	22.20	.776	.70	.657	.70	.787	20.97	.126	23.00:	69.026	.50	.234	.12	.652
.88	22.00	.780	.65	.658	.70	.791	21.10	.128	(22.7	.033	.57	.242	.14	.654
372.76	21.96	.804	.70	.679	.80	.813	20.97	.143	(22.7	.077	.50	.287	.12	.673
373.94	22.20	.835	.60	.705	21.70	.843	21.11	.161	22.75	.137	.70	.349	22.05	.693
394.69	.00	37.392	.40	30.153	22.70	35.369	.62	.496	(22.7	.181	.75	72.426	21.85	26.081
395.77	.13	.421	.60	.176	.80	.397	.65	.513	(22.5	.235	.87	.482	.87	.101
.94	.13	.425	.65	.180	.85	.401	.60	.516	(22.5	.244	.95	.491	.99	.104
396.68	.10	.445	.50	.197	.90	.420	.60	.528	(22.5	.281	.98	.530	21.92	.118
.84	-	-	.45	.199	.85	.424	.70	.531	22.70:	.289	-	-	22.06	.121
397.90	.11	.478	.60	.223	.85	.451	.64	.547	.40	.342	23.00:	.593	22.02	.140
403.84*	22.10:	.835	.10	.351	.00	.601	.60	.644	(22.3	70.641	23.00:	.901	21.90	.252
426.83*	21.50	38.252	.35	.848	22.00	36.184	.16	23.015	(22.3	71.798	22.44	74.095	.95	.682
450.69	22.45	.893	21.10	31.364	-	-	21.35	.400	(22.5	72.999	22.70	.334	21.90	27.128
5690.94	21.55	45.334	21.58	36.558	21.95	42.882	21.07	27.275	(22.7	85.088	(23.00	87.811	22.30	31.621
692.88	.65	.387	.30	.600	.90	.931	.13	.306	(22.7	.186	23.00	.911	.20	.657
693.88	.60	.413	.33	.622	21.90	.957	.14	.322	22.50	.236	22.70	.963	22.22	.675
715.78	.63	46.000	.20	37.095	22.80	43.512	.64	.675	.50	86.338	.40	89.100	21.85	32.085
716.77	.40	.027	.20	.117	.70	.537	.71	.691	.60	.388	.37	.152	.85	.104
717.79	.40	.054	.10	.139	.60	.563	.90	.708	.30	.439	.45	.204	.87	.122
718.77	.33	.080	.25	.160	22.60	.588	.84	.724	.20	.489	.52	.256	.87	.141
719.80	21.40	.108	.25	.183	21.90	.614	.68	.741	.20	.540	.58	.309	21.97	.161
808.78	22.12	48.493	21.35	39.106	21.80	45.871	21.04	29.176	(22.5	98.018	22.95	.929	22.10	33.825

TABLE B. Photovisual observations and phases of seventeen Cepheids and five Population II variables.

JD 2,430,000+	V 2 V	V 2 Phase	V 2 B−V	V 3 V	V 3 Phase	V 3 B−V	V 5 V	V 5 Phase	V 5 B−V	V 8 V	V 8 Phase	V 8 B−V	V 9 V	V 9 Phase	V 9 B−V
4596.95	21.42	136.672	+0.57	20.20	46.951	+0.65	20.08	46.490	+0.74	20.66	61.904	+1.04	20.50	70.154	+0.58
4932.92	21.36	213.592	.75	20.35	73.378	1.15	20.08	72.656	.85	20.66	96.744	1.01	20.91	109.635	.89
5009.78	.00	231.189	.38	.47	79.420	1.07	.10	78.642	.79	.72	104.714	.88	.76	118.669	1.00
011.75	21.36	.640	.67	.53	.575	1.33	.24	.796	1.10	.51	.918	.84	.42	.901	.52
035.78	20.75	237.142	.48	.50	81.465	1.20	.19	80.666	.79	.36	107.410	.68	.94	121.724	.88
036.90	-	-	-	.50:	.553	1.32	.40	.754	.76	.41	.527	.87	.30	.854	.75
037.66	21.29	.572	.69	.75	.613	1.10	.32	.813	1.07	.57	.605	.93	.35	.945	.35
065.67	.68	243.985	.38	.58	83.816	.86	.52	82.995	1.19	.24	110.510	.99	.45	125.237	.74
066.68	.04	244.216	.35	.57	.896	.91	.60	83.074	1.32	.50	.615	1.12	.55	.356	.86
068.67	.54	.672	.62	.02	84.052	.37	.49:	.238	1.35	.66	.821	1.01	.88	.590	.98
069.67	.79	.901	.51	.05	.131	.70	.50	.305	1.09	.56	.925	.89	.83	.708	.82
097.68	.00	251.314	.60	.32	86.334	.96	20.17	85.487	.80	.61	113.829	1.05	.30	128.999	.56
098.68	.29	.543	.64	.50	.412	1.09	19.99	.567	.65	.28	.933	.89	.35	129.117	.70
099.71	21.23	.779	.81	20.60	.493	1.20	20.03	.645	.92	20.16	114.040	.69	20.35	.238	.80
5370.93	21.65	313.874	.64	20.60	107.825	.86	20.25	106.768	.95	20.16	142.165	.62	20.35	161.112	.65
371.91	20.76	314.099	.47	.55	.903	.97	.40	.844	1.05	.11	.267	.57	.30	.227	.77
394.75	21.10	319.328	.68	.83	109.699	1.32	.07	108.623	.78	.61	144.636	.88	.40	163.911	.62
395.74	.23	.555	.81	.70	.777	.97	.10	.700	.95	.72	.738	.98	.30	164.027	.48
396.71	.54	.777	.62	.60	.854	.78	.25	.776	1.01	.56	.838	1.02	.45	.142	.66
397.87	21.39	320.042	.32	.45	.944	.55	.30	.866	1.13	.41	.959	.69	.55	.278	.73
450.72	20.76	332.142	.59	20.05	114.101	.61	20.50	113.983	1.43	20.38	150.440	.65	20.70	170.488	1.00
5687.95	21.42	386.456		20.70	132.759		20.42	131.457		20.24	175.040		20.70	198.368	
689.92	21.45	.907		20.65	.914		.10	.610		.20	.245		.83	.600	
690.90	20.78	387.131	.45	19.85	.991	.52	.06	.687	.98	.24	.346	.73	.72	.715	.98
691.88	21.29	.356		20.06	133.068		.32	.764		.36	.448		.70	.830	
692.91	.36	.592	.71	.15	.150	.60	.30	.844	.96	.46	.553	.89	.45	.951	.40
693.91	.45	.821	.71	.15	.228	.85	.25	.922	1.22	.56	.658	.94	.30	199.068	.70
715.81	21.48	392.835	.76	20.15	134.950	.65	.06	133.627	.69	.41	177.929	.99	.83	201.641	1.02
716.84	20.94	393.071	.44	19.95	135.031	.60	.15	.708	.89	.03	178.036	.72	.76	.764	.76
717.81	21.23	.293	.41	20.15	.107	.48	.32	.783	.90	.03	.137	.77	.53	.877	.54
718.85	.41	.531	.54:	.25	.189	.75	.40	.864	.92	.07	.242	.58	.31	202.000	.49
719.76	.29	.739	.66	.25	.261	.80	.47	.935	1.07	.24	.339	.81	.42	.107	.68
755.74	21.41	401.977		.20	138.091		.16	136.737		.20:	181.070		.30:	206.334	
808.75	20.65	419.113	.44	.35	142.260	.65	.35	140.865	1.12	.56	187.567	.94	.70:	.564	1.20
809.76	21.06	.344		.10:	.340		.40	.943		.72	.672		.83	.683	
837.70	.48	420.741		.70	144.537		.69	143.120		.56	190.569		.15	215.967	
838.65	21.54	.959		20.73	.611		20.60	.194		20.90	.668		20.45	216.078	
6048.95	20.83	469.107		20.15	161.152		19.88	159.579		20.46	212.476		20.62	240.793	
073.85	21.54	474.808		-	-		20.15	161.511		.20	214.058		21.00	243.719	
.94	.27	.829		.15	163.117		.12	.518		.22	.068		20.89	.729	
075.90	.00	475.277		.50	.272		.10	.671		.20	.271		.40	.960	
.93	-	-		-	-		.08	.673		-	-		-	-	
077.93	.41	.742		.50	.431		.34	.829		.28	.481		.45	244.198	
078.83	.29	.948		.60	.502		.40	.899		.36	.575		.50	.300	
102.90	.23	481.459		.47	165.395		.25	163.774		.24	218.071		.35	247.133	
103.96	.36	.701		.52	.478		.32	.856		.16	.181		.43	.257	
193.75	21.06	502.259		20.55	172.541		20.35	170.849		20.41:	227.492		20.55:	257.810	

1963AJ.....68..435B

TABLE B (*continued*)

JD 2,430,000–	V 10 V	V 10 Phase	V 10 B–V	V 11 V	V 11 Phase	V 11 B–V	V 13 V	V 13 Phase	V 13 B–V	V 15 V	V 15 Phase	V 15 B–V	V 17 V	V 17 Phase	V 17 B–V
4596.95	22.00	196.164	+0.55	21.25	200.479	+0.55	21.64	156.968	+0.43	19.75	28.075	+1.05	20.57	88.677	+0.66
4932.92	21.75	306.567	.58	21.23	313.311	.53	21.73	245.311	.85	19.40	43.875	.54	20.86	138.585	.92
5009.78	.88	331.824	.60	.17	339.123	.33	.71	265.522	1.13	20.33	47.490	1.09	20.86	150.003	1.05
011.75	.36	332.471	.61	.13	.785	.69	.46	266.040	.78	20.11	.583	1.14	21.00	.292	1.27
035.78	.37	340.368	.58	21.06	347.855	.72	.73	272.359	1.12	19.46	48.713	.43	20.53	153.865	1.02
036.90	-	-	-	20.94	348.231	.55	.75	.653	1.14	.31	.765	.52	.90	154.031	1.12
037.66	21.65	.985	.89	21.30	.487	.60	.48	.853	.82	.51	.801	.40	20.93	.144	1.20
065.67	22.10	350.190	-	.00	357.893	.78	.69	280.218	.94	.80	50.118	1.16	21.05	158.305	1.20
066.68	21.43	.521	.69	.00	358.232	.58	.81	.483	1.04	19.92	.166	1.27	21.20	.455	1.25
068.67	.81	351.175	.74	21.00:	.901	.70	.34	281.007	.78	20.20	.260	1.07	20.66	.750	.64
069.67	.60	.504	.45	20.90	359.236	.69	.84	.270	.81	.02	.307	1.24	.65	.900	.92
097.68	.72	360.708	.65	21.19	368.644	.72	.94	288.635	.89	20.25	51.624	1.11	.96	162.060	1.16
098.68	.90	361.037	.64	.08	.979	.43	.38	.898	.74	19.84	.671	.80	20.99	.209	1.18
099.71	21.23	.376	.59	21.06	369.326	.53	21.49	289.169	.91	19.35	.720	.45	21.06	.361	1.23
5370.93	21.59	450.501	.46	21.05	460.411	.66	21.90	360.486	.87	20.25	64.475	1.17	20.60	203.652	.75
371.91	.87	.823	.62	.15:	.741	.75	22.05	.744	.79	.25	.521	1.05	.60	.797	.80
394.75	.47	458.329	.53	.00	468.411	.70	21.82	366.750	.74	.33	65.595	1.17	20.80	207.190	1.36
395.74	.65	.654	.75	.16	.744	.83	.45	367.010	.81	20.38	.642	1.02	21.04	.337	1.18
396.71	.82	.973	.88	.05	469.070	.35	21.76	.265	.97	19.67	.687	.78	21.19	.480	1.31
397.87	.47	459.354	.43	.29	.459	.56	22.05	.570	.95	.40	.742	.30	20.60	.654	.60
450.72	21.71	476.721	.74	21.00	487.208	.57	21.59	381.467	1.21	19.98	68.227	1.24	21.10	215.504	1.03
5687.95	21.65	554.677		21.00	566.879		21.37	443.846		20.33	79.384		20.48	250.745	
689.92	.65	555.325		.16	567.541		.65	444.364		.40	.477		.82	251.037	
690.90	.65	.647	.75	.15	.870	.55	.95	.622	.85	.20	.523	1.25	20.85	.183	1.15
691.88	.65	.969		.11	568.199		.49	.880		.20	.569		21.25	.329	
692.91	.59	556.307	.61	.23	.545	.69	.76	445.151	.64	.20	.618	1.27	21.12	.481	1.05
693.91	21.56	.636	.64	21.15	.881	.65	21.92	.414	.83	20.00	.665	1.00	20.53	.630	.97
715.81	22.00:	563.832	.65	20.90	576.236	.71	22.00	451.172	.61	19.44	80.695	.71	.80	254.883	.70
716.84	21.93	564.171	.62	21.16	.582	.78	21.80	.443	.96	.23	.743	.52	.78	255.036	1.12
717.81	.41	.490	.64	21.10	.908	.50	.73	.698	.98	.28	.789	.54	20.82	.180	1.23
718.85	.76	.831	.74	20.87	577.257	.69	.66	.972	.37	.40	.838	.47	21.02	.335	1.03
719.76	.87	565.130	.88	21.34	.562	.57	21.92	452.211	.63	19.44	.880	.71	21.01	.470	1.19
755.74	.77	576.954		.31	589.646		22.02	461.672		20.20	82.572		20.57	260.815	
808.75	.20	594.373	.60	21.06	607.449	.79	22.10	475.611	-	19.75	85.066	.87	.45	268.690	.72
809.76	.78	.705		20.96	.788		21.41	.876		19.80	.113		.70	.840	
837.70	.77	603.887		20.93	617.171		.49	483.223		20.25	86.427		20.87	272.990	
838.65	21.76	604.199		21.10	.490		21.71	.473		20.16	.472		21.05	273.131	
6048.95	22.00	673.305		20.92	688.117		21.69	538.771		20.07	96.362		21.12	304.371	
073.85	21.48	681.488		21.22	696.480		.70	545.319		-	-		20.96	308.070	
.94	.59	.517		21.18	.510		.87	.343		.02	97.537		21.08	.084	
075.90	.82	682.161		20.94	697.168		-	-		20.16	.630		.15	.375	
.93	-	-		21.00	.178		.59	.866		-	-		21.12	.379	
077.93	.59	.828		.11	.850		.79	546.392		19.32	.725		20.57	.676	
078.83	-	-		.07	698.152		-	-		.40	.767		20.73	.810	
102.90	.94	691.034		.01	706.236		.56	552.957		.53	98.899		21.08	312.386	
103.96	.39	.382		21.17	.592		.69	553.236		.44	.949		21.06	.453	
193.75	21.90	720.888		-	-		21.44	576.846		19.84	103.172		20.62	325.882	
	V 21			V 27			V 30			V 31			V 36		
4596.95	21.75	178.315	+0.55	21.68	230.232	+0.58	20.37	46.353	+1.03	19.60	44.762	+0.59	21.94	166.125	+0.70
4932.92	21.97	278.673	.76	21.95	359.808	.73	20.20	72.445	.90	19.91	69.955	.64	21.76	259.622	.72
5009.78	.98	301.631	.83	.60	389.452	.56	20.50	78.409	.80	.58	75.718	.52	.94	281.011	.85
011.75	.55	302.220	.70	.58	390.212	.58	19.95	.562	.95	.75	.866	.70	.81	.560	.69
035.78	.76	309.398	.56	.64	399.480	.52	20.45	80.427	.75	.58	77.668	.58	.45	288.247	.66
036.90	-	-	-	.72	.912	.89	.00	.514	.80	.70	.752	.46	-	-	-
037.66	.36	.959	.28	.71	400.205	.49	.25	.573	.60	.68	.809	.67	.82	.770	.80
065.67	.78	318.326	.56	.68	411.008	1.05	.30	82.749	1.15	.85	79.909	.69	.62	296.565	.88
066.68	.82	.628	.81	.36	.398	.60	.25	.827	1.39	.85	.985	.81	.67	.846	1.10
068.67	.53	319.222	.63	.94	412.165	.74	.50	.982	1.32	19.95	80.134	.89	.77	297.400	.42
069.67	.86	.521	.62	.65	.551	.78	.55	83.059	1.45	20.07	.209	.81	.71	.678	.92
097.68	.53	327.888	.70	.45	423.354	.55	.47	85.235	1.23	19.97	82.310	.81	.60	305.473	.71
098.68	.47	328.187	.55	.74	.739	.85	.35	.312	1.20	.83	.385	.74	.77	.752	.95
099.71	21.70	.494	.74	21.87	424.137	.70	20.38	.393	1.09	19.80	.462	.66	21.82	306.038	.98
5370.93	21.82	409.510	.62	21.76	528.741	.74	20.15	106.452	.85	19.75	102.799	.52	21.71	381.516	.71
371.91	22.10	.803	-	.82	529.119	.78	.10	.530	.73	.73	.872	.64	.87	.788	1.02
394.75	21.71	416.626	.74	.88	537.927	1.00	.42	108.303	.98	.70	104.585	.50	.95	388.145	.80
395.74	.26	.921	.59	.44	538.309	.56	.47	.379	.95	.60	.660	.51	.65	.420	.59
396.71	21.82	417.211	.41	.76	.684	.89	20.05	.454	.85	.58	.732	.57	.88	.690	.84
397.87	22.05	.558	.65	.92	539.130	.83	19.93	.545	.87	.68	.819	.68	.95	389.013	.75
450.72	21.70	433.345	.77	21.67	559.514	.68	20.10	112.649	.99	19.62	108.782	.62	21.76	403.720	.84

TABLE B (*continued*)

JD 2,430,000+	V 21 V	V 21 Phase	V 21 B-V	V 27 V	V 27 Phase	V 27 B-V	V 30 V	V 30 Phase	V 30 B-V	V 31 V	V 31 Phase	V 31 B-V	V 36 V	V 36 Phase	V 36 B-V
5687.95	21.53	504.207		21.72	651.008		20.70	131.069		19.70	126.571		21.71	469.740	
689.92	.88	.796		.80	.768		.65	.222		.61	.719		.47	470.288	
690.90	.41	505.089	+0.49	.75	652.146	+0.85	.45	.298	+0.95	.73	.792	+0.45	.71	.560	+0.59
691.88	.77	.381		.73	.524		.45	.375		.70	.866		.95	.833	
692.91	.70:	.689	.95:	.78	.922	.77	.20	.454	.70	.90	.943	.65	.71	471.119	.99
693.91	21.29	.988	.36	.32	653.307	.60	.05	.532	.77	.91	127.018	.82	.65	.398	.45
715.81	22.07	512.530	.73	.70	661.756	.85	.52	133.232	1.08	.57	128.660	.56	.87	477.492	.43
716.84	21.92	.837	.68	.85	662.151	.72	.30	.312	1.07	.66	.737	.54	.82	.779	.83
717.81	.52	513.127	.56	.63	.524	.82	.45	.387	.95	.70	.810	.60	.87	478.049	.88
718.85	.87	.438	.68	.85	.926	1.05	.10	.458	.85	.85	.888	.54	.59	.339	.41
719.76	.72:	.709	.98	21.40	663.277	.43	.23	.539	.49	.80	.956	.75	21.76	.592	.74
755.74	.94	524.457		22.07	677.154		.20	136.333		.60	131.654		22.00	488.605	
808.75	.76	540.291	.67	21.65:	697.610	.75	.00	140.449	.95	.70	135.629	.52	21.45	503.357	.75
809.76	.94	.593		.82	.988		.15	.528		.60	.705		.94	.638	
837.70	.00	548.939		.56	708.764		.25	142.697		.70	137.800		.54	511.413	
838.65	21.47	549.223		21.86	709.130		20.35	.770		19.85	.871		21.71	.678	
6048.95	21.36	612.042		21.34	790.239		20.70	159.101		19.60	153.640		21.59	570.202	
073.85	21.84	619.480		22.00	799.842		.80	160.034		.72	155.508		-	-	
.94	22.00	.507		22.00	.877		.63	.041		.66	.514		.95	577.157	
075.90	21.35	620.092		-	-		.95	.193		.52	.661		-	-	
.93	-	-		21.87:	800.644		.75	.195		.52	.663		.76	.711	
077.93	22.00	.698		.23	801.416		.50	.351		.70	.814		.53	578.267	
078.83	21.19	.967		-	-		.65	.421		.80	.881		.87	.518	
102.90	.32	628.157		.87	811.046		.45	163.290		.60	157.686		.76	585.216	
103.96	.88	.474		.73	.445		.35	.372		.65	.765		.82	.511	
193.75	21.72	655.295		21.69	846.086		20.55:	170.345		19.72	164.498		21.59	610.499	

JD	V 46 V	V 46 Phase	V 46 B-V	V 48 V	V 48 Phase	V 48 B-V
4596.95	22.35	160.860		22.11	175.408	
4932.92	21.90	251.395	+1.00	22.00	274.129	+0.80
5009.78	22.40	272.105	-	21.94	296.714	.70
011.75	22.23	.636	-	22.02	297.293	.81
035.78	-	-	-	.07	304.355	.77
036.90	-	-		22.12	.683	-
037.66	21.98	279.619	.93	-	-	
065.67	22.40	287.166	-	21.94	313.137	.85
066.68	21.82	.437	.88	22.05	.434	.77
068.67	22.15	.973	-	21.94	314.019	.77
069.67	.57	288.243	-	22.11	.312	-
097.68	.15	295.792	-	22.07	322.543	1.07:
098.68	.35	296.061	-	21.88	.836	.39
099.71	22.18	.339	-	21.96	323.139	.88
5370.93	21.88	369.425	1.08	21.94	402.834	.42
371.91	22.11	.689	-	22.00	403.121	.75
394.75	.36	375.843	-	.00	409.833	.35
395.74	.35	376.110	-	.00	410.124	.75
396.71	.11	.372	-	.11	.408	-
397.87	.11	.684	-	.11	.750	-
450.72	22.00	390.925	1.10:	22.06	426.279	.84

JD 2,430.00+	V 46 V	V 46 Phase	V 46 B-V	V 48 V	V 48 Phase	V 48 B-V
5687.95	22.05	454.852		21.94	495.987	
689.92	22.05	455.383		22.00	496.566	
690.90	21.95	.647	.80	21.83	.854	.62
691.88	22.24	.912		22.05	497.142	
692.91	22.40	456.189		21.89	.444	.96:
693.91	21.71	.459	.84	21.88	.738	.72
715.81	22.35	462.359	-	22.05	504.174	.75
716.84	.05	.637	.70	.11	.477	
717.81	.11	.898	-	.00	.762	.50
718.85	.35	463.169	-	.00	505.067	.70
719.76	.00	.424	.70	.11	.335	
755.74	22.11	473.119		.00	515.907	
808.75	21.76	487.404	1.14	22.10	531.486	
809.76	22.17	.676		21.76	.782	
837.70	.46	495.206		21.82	539.990	
838.65	22.00	.462		22.23	540.270	
6048.95	22.70	552.130		22.00	602.063	
073.85	.23	558.840		-	-	
.94	22.11	.865		.11	609.407	
075.90	-	-		-	-	
.93	21.71	559.401		.05	.991	
077.93	22.11	.940		-	-	
078.83	-	-		-	-	
102.90	.23	566.670		.00	617.916	
103.96	22.35	.954		.11	618.228	
193.75	-	-		22.11	644.612	

JD	V 22 V	V 22 Phase	V 22 B-V	V 24 V	V 24 Phase	V 24 B-V	V 34 V	V 34 Phase	V 34 B-V	V 55 V	V 55 Phase	V 55 B-V	V 57 V	V 57 Phase	V 57 B-V
4596.95	21.23	16.004	+0.37	20.75	12.906	+0.90	20.88	9.629	+0.76	21.90	31.000	+0.62	21.18	11.163	+0.62
4932.92	21.70	25.012	.70	20.50	20.169	.86	20.60	15.048	.51	21.90	48.446	.88	21.47	17.446	.83
5009.78	.24	27.072	.50	.30:	21.832	.74	.37	16.288	.75	.65	52.439	1.06	.12	18.883	.68
011.75	.06	.125	.39	.35	.875	.65	.36	.319	.85	.88	.540	1.10	.06	.920	.83
035.78	.32	.769	.98	.78	22.394	.96	.93	.707	.76	.94	53.789	-	.30	19.369	.88
036.90	.59	.799	.77	.90	.417	.77	.65:	.725	1.05	-	-	-	.41	.390	.82
037.66	.20	.820	1.00	.65	.437	1.10	.66	.737	1.10	-	-	-	.22	.404	1.00
065.67	.27	28.571	.85	.56	23.039	.74	.43	17.190	.59	.76	55.341	.94	.38	.928	.70
066.68	.40	.598	.74	.42	.061	.88	.33	.206	.59	.65	.393	.83	.26	.947	.82
068.67	.26	.651	1.02	.55	.104	.67	.30	.238	.58	.88	.496	.85	.32	.984	.76
069.67	.42	.678	1.00	.43	.126	.90	.40	.254	.53	.88	.549	1.10	.05	20.003	.85
097.68	.27	29.429	.70	.59	.731	.65	.71	.706	1.02	.71	57.003	.99	.25	.527	.88
098.68	.04	.456	.94	.50	.753	.73	.94	.722	.86	.71	.055	.75	.30	.546	.88
099.71	21.11	.483	.84	20.55	.774	.60	20.70	.739	1.02	21.65	.108	.67	21.18	.565	1.00
5370.93	21.06	36.775	.78	20.70:	29.640	1.00	20.40	22.113	.57	21.82	71.193	.58	21.27	25.637	.88
371.91	.00	.781	1.00	.60	.661	1.05	.50:	.129	.60	.65	.243	.92	.18	.655	.95
394.75	.36	37.393	.64	.80	30.154	.60	.55	.497	1.07	.60	72.429	1.15	.23	26.082	.62
395.74	.20	.420	.93	.75	.175	.85	.70	.513	.92	.65	.481	1.22	.18	.100	.70
396.71	.40	.446	.70	.80	.198	.70	.84	.529	.81	.88	.531	1.10	.38	.119	.57
397.87	.29	.477	.82	.90	.222	.70	.65	.548	.99	.83	.591	1.17	.42	.140	.60
450.72	21.17	38.894	1.28	20.60:	31.365	.50	20.65	23.401	.70	21.60	75.335	1.10	21.36	27.129	.54

TABLE B (*continued*)

JD 2,430,000+	V 22 V	V 22 Phase	V 22 B−V	V 24 V	V 24 Phase	V 24 B−V	V 34 V	V 34 Phase	V 34 B−V	V 55 V	V 55 Phase	V 55 B−V	V 57 V	V 57 Phase	V 57 B−V
5687.95	21.00	45.254		20.75	36.493		20.55	27.227					21.39	31.565	
689.92	.06	.307		.85	.535		.45	.258		22.00	87.757		.50	.602	
690.90	.14	.333	+0.41	.75	.557	+0.83	.45	.274	+0.62	.26	.808	-	.42	.620	+0.88
691.88	.02	.359		.75	.579		.50	.290		.05	.859		.64	.638	
692.91	.06	.387	.59	.55	.601	.75	.52	.307	.61	(22.0	.912	-	.52	.658	.68
693.91	.08	.414	.52	.56	.623	.77	.53	.324	.61	22.10	.964	-	.50	.676	.72
715.81	21.17	46.001	.46	.52	37.096	.68	.88	.676	.76	21.59	89.001	+0.81	.35	32.086	.50
716.84	20.89	.028	.51	.60	.118	.60	20.83	.692	.88	.65	.156	.72	.30	.105	.55
717.81	21.00	.054	.40	.60	.140	.50	21.07	.709	.83	.65	.205	.80	.42	.123	.45
718.85	20.89	.082	.44	.50	.161	.75	20.73	.725	1.11	.54	.260	.98	.27	.143	.60
719.76	20.94	.107	.46	.50	.182	.75	.91	.740	.77	.40	.307	1.18	.29	.160	.68
755.74	21.06	47.071		.35	.960		.22	28.320		21.41	91.176		.60	.832	
808.75	.17	48.493	.95	.80:	39.106	.55	.34	29.175	.70	22.16	93.928	-	.42	33.824	.68
809.76	.13	.520		.50	.127		.37	.191		21.82	.981		.48	.843	
837.70	.11	49.269		.35	.731		.70	.642		.65	95.432		.42	34.365	
838.65	21.00	.294		20.55	.753		20.58	.657		21.65	.481		21.28	.383	
6048.95	21.06	54.932		20.60	44.298		20.50	33.050		21.82	106.402		21.21	38.315	
073.85	.66	55.600		.98	.837		.79	.451		-	-		.35	.781	
.94	.66	.602		.85	.839		.81	.454		22.23	107.700		.35	.783	
075.90	.76	.655		-	-		.70	.484		-	-		-	-	
.93	.65	.656		.70	.878		-	-		-	-		.40	.820	
077.93	.29	.709		.65:	.925		.76	.514		22.23	.907		-	-	
078.83	.29	.733		.80	.944		.83	.532		-	-		-	-	
102.90	.48	56.379		.50	45.465		.53	.920		21.53	109.204		.34	39.324	
103.96	.36	.407		.53	.487		.53	.937		21.64	.259		.33	.344	
193.75	21.36	58.814		20.25:	47.429		20.35	35.385		22.35	113.921		21.13	41.023	

TABLE C. Photographic observations and phases for ten eclipsing binaries.

JD 2,430,000+	V 1* B	V 1* Phase	V 12 B	V 12 Phase	V 23* B	V 23* Phase	V 29 B	V 29 Phase	V 35 B	V 35 Phase	V 60 B	V 60 Phase	V 7* B	V 40* B	V 44 B	V 45* B
4184.951	21.39	0.360	21.67	0.578	20.73	0.248	21.94	0.536	22.01	0.811	19.07	0.231	20.90	21.08	21.67	22.04
224.892	.10	.438	.60	.763	.88	.564	.64	.891	22.04	.966	.00	.680	.75	.25	.84	21.92
243.835			.62	.913	.86	.560	21.94	.482	21.79	.629	.15	.264	.72	.30	.88	22.38
244.833			.65	.343	.63	.718	22.18	.566	21.79	.033	.38	.400	.91	.35	.94	.18
245.842	.18	.480	.67	.777	.84	.877	21.65	.651	22.06	.441	19.04	.536	20.84	.10	.74	.24
.896	-	-	.54	.800	.84	.886	.56	.655	21.94	.463	18.98	.545	21.30	.29	.62	22.36
246.807			.60	.192	.98	.030	.69	.732	22.12	.831	19.00	.669	20.83	.10	.73	21.96
277.749	.19	.542	.88	.505	.90	.923	.72	.331	22.80	.347	19.44	.890	.83	.17	.69	22.73
304.697			21.75	.099	.81	.185	.84	.594	21.82	.247	18.91	.567	.87	.13	.86	21.94
305.659	.48	.597	22.10	.514	.90	.337	.54	.675	.76	.636	.94	.698	.84	.17	.76	22.28
330.699*	-	-	21.57	.287	.78	.297	.60	.779	21.85	.765	.90	.114	.74	.12	-	21.98
334.638	.65	.654	22.06	.982	.84	.920	.48	.110	22.79	.358	18.92	.651	20.80	21.13	.67	22.38
360.615			21.45	.159	.75	.028	21.57	.292	.00	.865	19.02	.195	21.01	20.98	.58	.04
361.607	21.55	.706	.52	.586	.73	.184	22.00	.375	.01	.267	.34	.330	20.77	20.95	.77	.18
362.673	-	-	21.88	.045	20.88	.353	22.18	.465	22.03	.698	19.02	.476	20.81	21.45	21.72	22.08
4596.913	(22.5	.166	21.60	.831	20.91	.396	21.55	.141	21.97	.445	19.38	.431	20.72	21.00	21.74	22.17
597.877	"		.53	.219	.78	.548	.54	.222	22.16	.835	.00	.562	20.71	20.88	.72	21.92
598.878	"		.63	.250	.86	.707	.33	.306	21.90	.240	.02	.699	21.39	.91	.60	.84
599.875	"		.66	.105	.88	.864	21.60	.390	.98	.643	.43	.835	20.78	.72	.69	21.84
600.880	"	.174	21.78	.539	.91	.023	22.00	.474	.97	.050	19.18	.972	.68	.94	.72	22.75
601.956	"		22.01	.000	.80	.193	21.70	.564	21.91	.485	18.97	.119	.72	.84	.80	.16
602.878*	"		21.57	.397	20.84	.339	.50	.642	22.10	.858	19.05	.245	.85	.91	-	.18
625.772*	"	.223	-	-	21.11	.960	.75	.565	21.80	.118	.40	.368	.95	-	-	-
.889	"		.61	.298	21.15	.978	.77	.575	.84	.165	.51	.384	.77	.86	.80	.20
626.769	"		.63	.650	20.80	.117	.65	.648	.95	.521	.02	.504	.87	.88	.74	.28
.875*	"		.50	.696	.80	.134	.50	.658	21.90	.564	19.00	.518	.92	-	-	-
627.763	"	.227	.60	.104	.81	.274	.67	.732	22.07	.923	18.90	.639	.76	.97	.89	-
628.910	"		21.65	.598	.97	.456	.60	.828	22.34	.388	19.27	.796	.74	.97	.67	.78
629.764	"		22.16	.965	.72	.591	.88	.900	21.94	.733	.33	.912	.70	.94	.67	.14
630.783	"	.233	21.64	.404	.76	.752	.76	.986	21.78	.145	.02	.051	.89	.92	.78	22.08
633.761	"		.60	.685	.81	.223	.52	.236	22.80	.350	19.15	.458	.68	.92	.56	21.80
634.845	(22.5	.241	.57	.151	.88	.394	.58	.327	22.01	.788	18.93	.606	.68	.90	.70	21.86
660.749	21.31	.292	.62	.271	20.92	.491	.98	.503	21.98	.266	19.02	.139	.70	.95	.74	22.04
663.795	.50	.297	.54	.608	21.06	.973	.50	.759	21.93	.498	18.90	.555	.88	.92	.70	.08
680.640	.23	.331	.56	.856	20.69	.636	.62	.174	22.44:	.312	19.40	.853	.91	.94	.64	.36
681.690			.52	.308	20.69	.802	.52	.262	21.98	.737	19.02	.996	.85	.83	.48	.53
682.659			21.48	.726	21.05	.956	.90	.343	21.84	.128	18.90	.128	.81	.87	.58	.02
714.625*			22.00	.478	-	-	.60	.029	-	-	19.00	.489	-	.87	-	-
717.609			21.65	.563	20.92	.483	21.69	.279	22.02	.266	.32	.896	.75	.82	.61	.02
718.625	21.15	.405	21.64	.199	20.76	.643	22.06	.365	22.06	.677	19.07	.035	20.79	20.90	21.50	22.06

TABLE C (*continued*)

JD 2,430,000+	V 1* B	V 1* Phase	V 12 B	V 12 Phase	V 23* B	V 23* Phase	V 29 B	V 29 Phase	V 35 B	V 35 Phase	V 60 B	V 60 Phase	V 7* B	V 40* B	V 44 B	V 45* B
4923.949			21.73	0.543	20.90	0.113	21.60	0.612	21.95	0.728	18.90	0.045	20.88	20.97	21.52	22.32
924.953			22.04	.975	.70	.272	.52	.696	.86	.134	18.97	.182	.87	21.06	.52	21.98
925.952	21.37	0.810	21.70	.405	.92	.430	.56	.780	.98	.538	19.28	.318	.73	20.92	.52	22.36
926.947			.52	.833	.81	.587	.92	.863	21.88	.941	19.15	.454	.80	20.95	.82	22.38
927.950*	-	-	.45	.265	.78	.746	.80	.948	22.60:	.346	18.90	.591	.77	21.00	-	-
928.945			.60	.793	.82	.903	.72	.031	22.00	.748	19.10	.727	.85	.11	.65	21.94
929.952	.27	.818	.60	.126	.85	.063	.72	.116	21.83	.155	.38	.864	.90	21.00	.58	.90
930.955			21.67	.558	.91	.221	.50	.200	.96	.561	19.09	.001	.87	20.81	.72	.92
931.945			22.04	.984	.72	.378	.57	.283	21.80	.962	18.94	.136	.84	21.00	.80	.98
932.955	.33	.824	21.71	.418	20.88	.537	.62	.368	22.44	.371	19.15	.274	.85	20.94	.64	21.90
954.969	.69	.867	.60	.890	21.00	.019	.80	.217	22.14	.275	.24	.277	.84	20.98	.58	22.20
981.876	.20	.920	.92	.467	20.78	.274	.82	.478	21.90	.158	.07	.948	.87	.95	.69	.08
983.862			.50	.321	.88	.588	.67	.644	21.92	.961	.15	.218	.77	.92	.69	.16
984.917			.49	.775	.76	.755	.56	.733	22.20	.389	.61	.362	.74	.95	.70	.02
985.865	.22	.928	.62	.183	.84	.905	.62	.813	.00	.772	.06	.492	20.97	.85	.67	.24
.977			.47	.231	.82	.922	.46	.822	22.08	.818	.03	.507	21.19	-	.78	22.16
5006.785			.60	.184	.81	.213	.69	.570	21.96	.235	.49	.346	20.69	20.87	.78	21.88
007.805	.11	.971	.52	.623	.90	.358	.50	.656	.86	.647	19.20	.485	.97	21.00	.85	22.28
008.789			21.70	.046	.83	.530	.49	.738	.96	.045	18.90	.619	.85	20.90	.64	.04
009.819	.17	.974	22.12	.490	.76	.693	.62	.825	21.98	.462	19.12	.760	.81	.80	.64	.10
010.764			21.54	.896	.78	.842	21.82	.904	22.11	.844	.32	.888	.70	-	.64	.06
011.794			.64	.339	.98	.005	22.00	.991	.00	.261	.10	.029	20.81	.92	.69	.36
035.735			.58	.640	20.74	.791	21.76	.002	22.01	.944	.24	.295	21.35	.85	.64	.32
036.868	.15	.027	21.60	.128	21.32	.965	.69	.097	21.96	.403	19.21	.450	21.26	20.98	.76	.48
037.702			22.12	.487	20.81	.102	.54	.167	21.90	.740	18.88	.563	20.87	21.01	.67	.18
.838			21.80	.545	.80	.124	.43	.178	22.16	.794	.82	.582	.78	-	.67	.20
038.702	.33	.031	.58	.917	.74	.260	.62	.251	21.88	.144	18.93	.700	.73	20.92	.65	.73
064.633			21.65	.074	.81	.361	.72	.429	.94	.632	19.11	.237	.75	21.17	.56	.16
065.628	.45	.084	22.03	.502	.76	.518	.92	.513	21.86	.035	.40	.373	.69	20.94	.77	.14
066.632			21.76	.934	.72	.677	.58	.597	22.00	.442	19.07	.510	20.72	21.11	.80	.06
067.624			.49	.361	20.73	.834	.65	.680	22.10	.843	18.86	.645	21.02	.04	.64	.16
068.623	.50	.090	.64	.791	21.00	.992	21.64	.764	21.96	.247	19.15	.782	20.76	.04	.70	.32
069.626			.50	.222	20.76	.150	22.00	.848	.82	.653	.20	.918	20.83	21.06	.79	22.48
.814			.54	.303	.77	.180	21.84	.864	.93	.729	.12	.944	21.06	20.87	.82	21.92
097.625	.67	.147	.57	.269	.81	.578	.45	.200	.90	.978	.07	.738	20.78	21.10	.64	22.28
.760			.50	.327	.90	.600	.52	.212	21.86	.032	.10	.756	21.06	-	.64	.14
098.639			.50	.705	.81	.739	.72	.294	22.36	.388	.43	.876	20.77	20.97	.70	.06
099.661	21.70	.151	.54	.145	.82	.900	.82	.372	22.10	.802	19.03	.016	.70	21.11	.76	.02
100.685			21.63	.586	20.86	.062	21.96	.458	21.99	.216	18.90	.155	20.81	20.98	21.83	22.40
5342.822	21.30	.626	21.65	.769	20.81	.354	21.67	.797	22.00	.158	19.06	.188	21.01	21.11	21.72	22.28
370.886			.56	.844	20.84	.792	.64	.154	.02	.510	19.02	.016	20.84	.11	.78	.04
371.738	.38	.683	.64	.211	21.00	.927	.40	.226	22.10	.854	18.85	.132	.74	-	.70	-
.810			.57	.242	.05	.938	-	-	21.98	.884	18.93	.142	20.77	.04	.73	-
.876			.63	.270	21.11	.948	.48	.238	21.89	.911	19.03	.151	21.10	-	-	.00
372.760	.49	.685	.46	.651	20.78	.088	.60	.312	22.12	.268	.11	.272	20.72	.21	.64	22.73
.914			-	-	.78	.113	.50	.325	22.63	.330	.30	.293	.74	-	-	21.96
373.936			.60	.157	.84	.274	.90:	.411	21.92	.744	.35	.432	.98	.65	-	22.63
394.687	.35	.728	.55	.085	.75	.556	.55	.154	.90	.137	.05	.263	.78	.11	-	.63
395.766			.81	.549	.82	.726	.45	.244	.85	.573	.30	.410	.74	-	-	.73
.866			.50	.592	-	-	.57	.253	.87	.614	.24	.424	20.99	-	.76	-
.937			.55	.623	.76	.753	.55	.259	.85	.643	19.25	.434	21.31	21.31	.73	.36
396.679			21.85	.942	.88	.871	.80	.321	.96	.943	18.90	.535	20.80	-	-	-
.843	.25	.732	22.20	.013	-	-	.62	.335	21.88	.009	18.82	.557	.74	-	.65	-
397.704			22.25	.469	.80	.064	21.90	.424	22.00	.438	19.00	.702	20.80	20.97	-	-
403.839*	.38	.746	21.90	.023	.88	.003	22.00	.923	-	-	19.00	.512	21.40	21.11	-	-
426.834*	.20	.791	.60	.916	.72	.639	21.80	.854	21.80	.140	18.90	.648	.20	21.04	-	-
450.686	21.48	.838	21.50:	.179	20.86	.412	21.75	.858	22.10	.788	19.20	.903	21.30	20.97	-	22.08
5690.944	21.65	.307	21.65	.555	20.88	.406	21.85	.039	21.90	.970	19.00	.678	20.80		21.80	22.34
692.881			.60	.388	.75	.712	.63	.202	22.01	.754	19.16	.943	.75		.63	.04
693.877	.54	.313	.66:	.816	.85	.870	.55	.286	21.83	.156	18.97	.078	.72		21.78	22.21
715.782			.50	.241	.75	.333	.40	.125	.80	.017	19.00	.067	.80			
716.771	.63	.358	.50	.667	.90	.490	.70	.209	.90	.417	.00	.201	.70			
717.787			21.60	.104	.70	.650	21.60	.294	.95	.828	.30	.340	20.75			
718.772			22.10	.528	20.90	.806	22.00	.377	.85	.226	19.20	.474	21.00			
719.802	.45	.364	22.00	.971	21.20	.969	21.85	.463	.90	.643	18.90	.615	.20			
808.782	21.45	.538	21.60	.256	20.85	.040	21.80	.937	21.80	.634	19.05	.753	21.06			
6103.915	21.30	.116	21.45	.241	20.90	.713	21.45	.729	21.80	.012	19.00	.016	20.75			
104.959			.50	.690	.80	.878	.70	.817	.90	.434	18.90	.159	21.75			
128.720			21.55	.914	20.80	.636	21.70	.812	21.90	.045	19.26	.400	21.40			

Photovisual Observations

	V 1* V	V 1* Phase	V 12 V	V 12 Phase	V 23* V	V 23* Phase	V 29 V	V 29 Phase	V 35 V	V 35 Phase	V 60 V	V 60 Phase	V 7* V	V 40* V	V 44 V	V 45* V
4596.949	(22.0	.166	21.48	.846	21.00	.402	21.72	.144	21.90	.460	19.52	.436		21.0	21.57	21.75
097.677	22.0	.147	.45	.292	20.82	.587	.66	.205	.79	.999	.36	.745			.80	-
5690.899	21.5	.307	.75	.535	.97	.399	.67	.036	.84	.952	.22	.672			.73	22.09
716.844	.55	.358	21.61	.698	20.98	.502	21.78	.215	21.99	.446	19.25	.212			21.90	-
6103.915	21.6	.116														
128.720	(22.0	.164														
193.751	21.7	.292														

Table D. Magnitudes and colors of 546 stars in Field IV, M31.

Star A	V	B–V	Star A	V	B–V	Star A	V	B–V	Star A	V	B–V	Star A	V	B–V	Star A	V	B–V	Star A	V	B–V
1	20.41	1.57	48	21.93	-.09	86	20.63	-.09	137	19.54	-.01	178	20.56	.87	240	18.50	.02	280	21.61	.14
2	21.91	.04	49	21.19	.09	87	20.84	-.21	138	21.43	.77	179	15.62	.51	241	18.18	.82	281	21.30	.82
3	21.94	.99	50	20.71	1.57	88	20.13	1.69	139	20.09	1.57	180	20.74	1.60	242	21.23	-.06	282	21.18	-.04
4	21.52	.69	51	21.64	.10	89	21.26	.65	140	18.06	.53	181	20.07	.40	243	19.26	2.20	284	18.82	1.86
5	19.58	1.23	52	20.79	.03	90	21.53	.01	141	18.95	1.47	182	Galaxy		244	19.76	.77	285	21.65	.11
7	21.71	.17	53	20.88	.18	91	21.70	.25	142	21.68	-.09	183	19.03	.68	245	20.95	.28	287	21.72	.00
9	22.15	-.04	54	21.50	-.06	92	18.75	1.72	143	16.21	1.39	184	20.78	.10	246	20.54	.19	288	21.32	-.11
10	19.18	.03	54a	21.85	.00	93	21.65	.07	144	21.34	-.08	185	18.86	.45	247	21.02	-.01	289	20.23	1.63
11	22.16	-.01	55	20.35	.17	94	21.27	-.15	145	20.78	-.09	186	20.89	.07	248	21.89	-.06	290	21.09	-.09
12	21.59	1.13	56	19.90	-.06	96	21.76	.47	146	20.24	1.54	200	19.68	.02	249	21.55	-.08	291	20.92	1.47
13	20.97	1.51	57	19.98	1.23	97	20.23	.27	147	21.88	.02	201	21.17	.12	250	21.54	.00	292	21.86	.06
14	21.72	-.11	58	19.44	.03	98	20.14	.82	148	21.16	1.35	203	19.50	-.20	250a	21.83	.28	293	21.37	.32
15	19.01	.81	59	21.16	1.36	99	21.05	1.48	149	21.51	1.49	205	21.78	-.04	250b	21.37	.02	294	21.90	.01
16	20.88	1.60	60	21.95	.39	100	21.02	.96	150	21.84	-.03	206	20.06	-.05	251	21.41	1.22	295	19.36	-.03
17	21.67	1.05	61	21.46	.03	101	21.21	1.37	151	20.30	.41	207	17.25	.50	252	20.04	.02	296	21.24	.06
19	20.83	1.37	61a	21.79	.12	102	20.90	1.67	152	20.89	1.30	208	21.42	-.04	253	21.33	.02	297	21.15	.06
22	20.24	.27	61b	20.87	.25	105	18.45	1.28	153	20.11	1.65	209	20.71	-.02	254	20.64	-.05	298	21.50	-.04
23	20.33	1.51	61c	21.24	1.41	106	21.09	1.27	154	20.40	.79	210	21.92	-.05	255	21.44	-.06	300	20.29	1.42
25	20.94	.32	62	19.63	1.72	107	21.47	1.13	155	18.84	1.65	211	20.46	-.12	256	20.97	-.11	301	19.61	1.70
26	18.20	1.60	63	20.33	1.73	108	21.74	1.08	156	20.70	1.49	212	21.12	1.57	257	20.94	-.05	302	19.75	-.05
27	20.75	.01	64	21.14	1.31	109	21.65	1.28	157	18.08	1.62	213	21.87	.01	258	19.73	.75	303	21.50	.42
28	20.13	-.05	65	21.58	-.07	110	21.16	1.17	158	20.60	1.54	214	19.92	1.72	259	20.91	-.17	304	21.51	1.04
29	17.75	.95	66	20.98	1.62	111	16.45	.73	159	22.06	-.10	215	21.73	.07	260	21.23	-.06	305	20.64	-.09
30	21.34	-.05	67	20.81	1.63	112	20.58	1.64	160	20.94	1.50	216	19.61	1.83	261	21.89	-.13	306	15.38	.67
31	21.52	.29	68	21.83	.64	113	21.23	1.28	161	20.43	.39	217	20.66	1.58	262	20.53	-.10	307	19.42	.78
32	21.20	1.17	69	20.33	1.82	120	21.35	1.19	162	20.69	1.01	219	21.60	.00	263	20.11	-.12			
33	21.46	-.15	70	21.88	.39	121	20.51	1.70	163	19.94	.30	222	19.32	1.61	265	20.91	-.04			
34	21.94	-.08	71	19.46	.94	123	19.90	1.66	164	21.03	-.04	223	19.28	-.04	267	21.03	1.44			
35	21.37	-.19	73	21.34	.04	124	20.94	.71	166	20.81	1.36	225	21.39	.61	268	21.53	1.22			
36	20.11	1.28	74	18.89	1.50	125	18.37	1.63	167	21.52	-.18	226	21.23	.34	269	21.73	-.06			
37	21.09	-.05	75	18.47	.39	126	21.58	1.10	168	21.69	-.06	227	21.91	.62	270	19.99	1.62			
38	21.38	.10	76	16.58	.59	127	21.87	-.07	169	20.98	.29	228	21.47	1.21	271	20.86	.34			
39	20.39	.02	77	21.27	-.13	128	20.48	1.59	170	17.90	.73	230	20.92	1.77	272	20.76	-.02			
40	21.07	.02	78	19.05	.86	129	18.60	1.53	171	20.11	-.06	232	19.14	-.18	273	21.81	.11			
41	21.02	1.54	79	18.61	.93	130	21.70	.05	172	19.88	-.23	233	18.42	.84	274	20.81	1.58			
42	21.95	-.11	80	21.79	-.15	131	19.46	.73	173	21.13	1.48	234	21.04	-.08	275	21.18	1.44			
43	21.51	.06	81	19.28	.61	132	20.61	1.56	174	21.45	-.04	236	21.97	.01	276	21.82	.06			
45	21.70	-.03	82	20.75	1.63	134	21.48	-.19	175	19.23	.81	237	21.23	.03	277	21.77	-.14			
46	21.11	-.09	83	20.63	1.42	135	18.87	1.15	176	21.45	-.17	238	21.40	1.31	278	21.81	-.13			
47	20.69	.19	85	21.89	.06	136	21.31	-.08	177	20.68	-.04	239	20.66	-.16	279	21.67	.01			
B			B			B			B			B			B			B		
1	21.37	-.17	41	19.05	-.29	76	21.81	.07	117	17.22	1.51	156	21.02	1.27	202	20.71	1.68	244	21.15	.38
2	17.03	.80	42	21.19	-.01	77	21.64	-.11	118	17.51	.54	159	20.35	1.74	203	21.12	.09	245	20.64	1.42
3	21.73	.71	43	21.39	-.11	78	21.41	.08	119	21.31	1.32	160	17.49	.98	204	21.16	1.48	246	21.58	.71
4	19.41	1.81	44	21.06	-.05	79	17.43	.65	120	21.29	1.47	162	20.97	1.55	205	21.61	.83	247	19.06	.93
5	21.87	-.05	45	21.76	-.13	80	19.09	1.61	121	21.40	.19	163	21.43	-.23	206	20.51	.69	248	21.74	.00
6	21.24	1.42	46	20.04	-.15	81	16.65	.65	122	21.10	1.46	165	21.85	-.08	207	21.71	1.16	249	19.60	.70
7	18.07	.59	47	21.85	1.01	82	21.92	-.01	123	21.46	1.44	166	20.88	1.51	208	21.70	1.22	250	18.56	.82
8	21.66	-.12	48	20.41	-.11	83	21.66	-.10	124	17.11	.55	167	20.81	.45	209	17.41	1.05	252	19.10	1.65
9	21.79	-.11	49	17.65	.87	84	21.75	-.03	125	17.61	.70	168	20.22	1.77	210	21.40	.19	253	21.92	1.18
10	20.61	.22	50	21.84	.23	85	20.14	1.25	126	16.93	.44	169	20.31	1.72	211	21.90	.14	254	21.55	1.29
11	21.29	-.07	51	18.99	2.13	86	21.69	.00	127	21.43	1.25	170	20.84	.46	212	21.41	.26	255	20.56	1.57
12	21.85	.12	52	20.53	-.09	87	20.17	.02	128	17.86	1.58	171	20.66	.16	213	20.52	1.52	256	20.65	.20
13	21.46	-.02	53	21.76	.11	88	21.36	.11	129	20.61	1.58	172	21.00	1.44	214	21.93	.29	257	19.74	1.76
14	20.59	-.16	54	20.67	-.08	89	21.45	.12	130	18.20	.54	173	20.43	-.12	215	21.22	1.17	258	19.14	1.45
15	21.42	.08	55	21.29	.11	90	21.57	.13	131	16.93	.63	174	19.98	.56	216	18.99	.52	259	18.46	1.69
16	19.90	-.15	56	20.42	-.03	91	20.24	.73	132	19.74	1.50	176	21.09	1.34	217	17.07	.68	260	20.10	1.65
17	21.79	-.05	57	20.16	-.14	92	21.87	-.06	133	15.41	.94	177	21.69	-.02	218	20.22	-.02	261	21.90	.84
18	19.27	-.10	58	21.84	-.11	93	20.78	-.25	134	21.55	1.36	178	18.44	.58	219	20.76	.53	262	21.16	1.24
19	19.19	-.19	59	17.84	-.15	94	19.08	1.77	135	21.48	1.51	179	18.84	.60	220	16.28	.97	263	17.02	.64
20	20.73	-.22	60	21.54	-.07	95	19.40	1.06	136	21.23	.72	180	21.41	-.14	221	21.72	.57	264	19.97	1.43
21	21.61	-.01	60a	20.08	-.09	96	19.33	1.80	137	20.94	1.62	182	20.79	1.63	222	20.72	1.53	265	21.85	.02
22	20.01	.97	60b	21.81	.09	97	21.88	.15	138	19.18	1.77	183	20.52	.13	223	21.34	1.38	266	20.37	-.24
23	21.58	-.09	61	20.09	1.72	98	21.75	.91	139	21.60	1.13	184	17.60	.64	224	21.06	1.51	267	20.62	.62
24	18.63	-.19	62	21.10	-.04	99	18.88	2.04	140	20.92	.60	185	21.70	-.08	225	20.93	1.50	268	21.71	-.11
25	21.96	.10	63	20.57	-.22	100	21.94	-.12	141	21.55	1.25	186	21.89	.99	226	20.27	-.02	269	21.27	1.49
26	19.80	-.21	64	19.61	-.29	101	21.65	.27	142	19.04	1.56	187	21.01	1.58	227	21.27	1.06	270	17.08	.99
27	21.91	-.11	65	21.94	-.08	102	20.37	1.18	143	18.03	.58	188	21.44	.39	228	18.31	1.15	271	18.39	1.58
28	21.17	-.03	66	21.93	-.12	103	17.90	1.08	143a	21.74	1.21	189	19.87	.56	229	21.95	.67	272	21.15	1.45
29	20.56	1.60	67	21.41	-.07	104	21.66	.02	144	21.17	1.51	190	19.36	1.85	230	18.58	1.77	273	21.04	1.73
30	21.00	.16	68	21.84	.08	106	21.65	-.14	145	20.01	1.65	191	18.81	1.43	231	21.21	.57	274	21.59	1.11
31	21.97	.00	68a	21.85	.03	107	21.09	-.07	146	21.77	.73	192	21.61	.03	232	21.52	.76	275	21.52	1.30
32	21.76	.27	69	20.90	-.20	108	16.72	.43	147	21.32	1.52	193	21.44	.55	234	20.35	1.07	276	21.99	.59
33	19.08	-.19	69a	16.19	.80	109	19.88	.86	148	20.46	.93	194	21.12	.38	236	21.95	.01	277	21.54	1.43
34	19.96	1.51	69b	20.63	.04	110	17.39	.88	149	20.62	.01	195	21.85	.31	237	21.17	.36	278	21.95	.05
35	21.45	-.19	70	20.95	-.01	111	21.20	1.40	150	21.03	-.19	196	21.34	1.17	238	21.85	-.15	279	21.70	.67
36	21.85	.15	71	19.42	-.26	112	20.02	1.66	151	20.04	-.17	197	21.63	.13	239	21.41	-.04	280	20.87	-.01
37	21.67	-.12	72	20.58	-.04	113	19.86	1.69	152	21.73	1.28	198	18.22	.34	240	20.18	1.56	281	19.66	1.70
38	17.47	.91	73	19.94	1.79	114	19.42	1.62	153	21.57	-.14	199	18.89	.76	241	21.21	1.51	282	21.22	.20
39	20.06	-.20	74	19.78	-.29	115	21.36	1.54	154	21.63	1.15	200	18.53	1.34	242	21.91	.85	283	20.32	1.07
40	21.30	-.06	75	21.07	.31	116	20.88	1.62	155	21.61	-.18	201	21.18	1.51	243	16.71	.62	284	20.87	1.70

Note on Planetary Nebulae in M 31

LITTLE can be added to Baade's report (1955) on five planetary nebulae that he found in Field IV in M31. They have been marked on the chart (Plate I of the preceding paper) and are numbered using a prefix PL. Table I lists new magnitudes for them based on Arp's photoelectric sequence and measured in the same way as the variables. The apparent magnitudes are uncorrected for reddening.

Table I.

	B	V	$B-V$	M_B
PL 1	22.2:	...	...	−2.65
2	22.2	21.5	+0.7	2.65
4	22.4	21.3	+1.1	2.35
5	22.3	21.7	+0.6	2.55
6	22.3	21.0	+1.3	−2.55
Mean	22.3	21.4	+0.9	−2.55

Both the B and V magnitudes are very sensitive to whether the emission lines are included or cut off by the combination of plate and filter used. The conversion of these B magnitudes to the International system used in planetary nebulae catalogues has not been attempted as the measured magnitudes are excitation dependent.

REFERENCE

Baade, W. 1955 *Astron J.* **60**, 151.

Henrietta H. Swope

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Distribution of Stars in the Leo I Dwarf Galaxy

Paul W. Hodge
Berkeley Astronomy Department, University of California
(Received 18 June 1963)

The distribution of resolved stellar images in the dwarf galaxy Leo I has been determined from star counts on seven plates. The galaxy is elliptical in outline and perfectly symmetrical within the observational uncertainties. The ellipticity is approximately uniform from the center outwards with a value of ϵ of 0.31±0.07. The star density profile of the Leo I system resembles those of other dwarf elliptical galaxies, and is unlike those for giant ellipticals. If the distance to the system is 230 kpc, then the observed sharp cutoff in radius at 14.3 min±1.0 min, along the major axis, corresponds to a linear cutoff radius of 0.95±0.07 kpc. This is somewhat smaller than the computed present tidal radius.

I. INTRODUCTION

THE Leo I galaxy (Fig. 1) is the fourth object to be studied in an attempt to determine and understand the structure of dwarf elliptical galaxies. The three previous galaxies studied (Hodge 1961a, 1961b, 1962) were found to be remarkably similar in their structural properties. All showed a steeper profile than predicted by a Hubble luminosity law and all had a distinct cutoff at a distance near to, but somewhat smaller than what one predicts from tidal considerations. In the local group of galaxies the two most distant known dwarf ellipticals are the Leo I and Leo II systems discovered in 1950 (Harrington and Wilson 1950). Leo I, although brighter than Leo II, has not been extensively studied because of its proximity to the star Regulus, which makes photography of the system difficult for large telescopes with correcting lenses. Baade (1950) obtained a few plates of it with the 200-inch telescope, using diaphragms in the optics to cut down reflections from Regulus. He estimated that the distance to the galaxy is about the same as that of the Leo II system, for which Sandage (1961) quotes a distance modulus of $m-M=21.8$, corresponding to 230 kpc. Baade found a few RR Lyrae variables, and no evidence for globular clusters or dust or gas. Many RR Lyrae variables have been found at Berkeley using 120-inch plates and these are presently being studied; periods and light curves are not yet available. There is a diffuse object near the major axis of Leo I, but this is apparently unrelated to the system; on the best 120-inch plates it has the appearance of a distant spiral galaxy. The total apparent magnitude of Leo I has been measured by Holmberg (1958), who finds $m_v=10.40$ and $CI=+0.87$. The dimensions from Holmberg's data are 12.0 min by 9.5 min; these compare with Harrington and Wilson's estimate of a diameter of 17 min. Accepting a distance of 230 kpc leads to a value for the absolute visual magnitude of the system of $M_v=-11{\cdot}4$, and the linear dimensions determined by Holmberg become 830 by 650 pc. Intrinsically Leo I is an exceedingly small, very faint object, though brighter by 1.5 mag. than Leo II.